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Aggregate Resources Inventory
Paper 67

Aggregate Resources Inventory of the Town of Dunnville Regional Municipality of Haldimand-Norfolk Southern Ontario

By Staff of the Engineering and Terrain Geology Section
Ontario Geological Survey

1984

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Ministry of Natural Resources
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Minister
John R. Sloan
Deputy Minister

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Every possible effort is made to ensure the accuracy of the information contained in this report, but the Ministry of Natural Resources does not assume any liability for errors that may occur. Source references are included in the report and users may wish to verify critical information.

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ABSTRACT

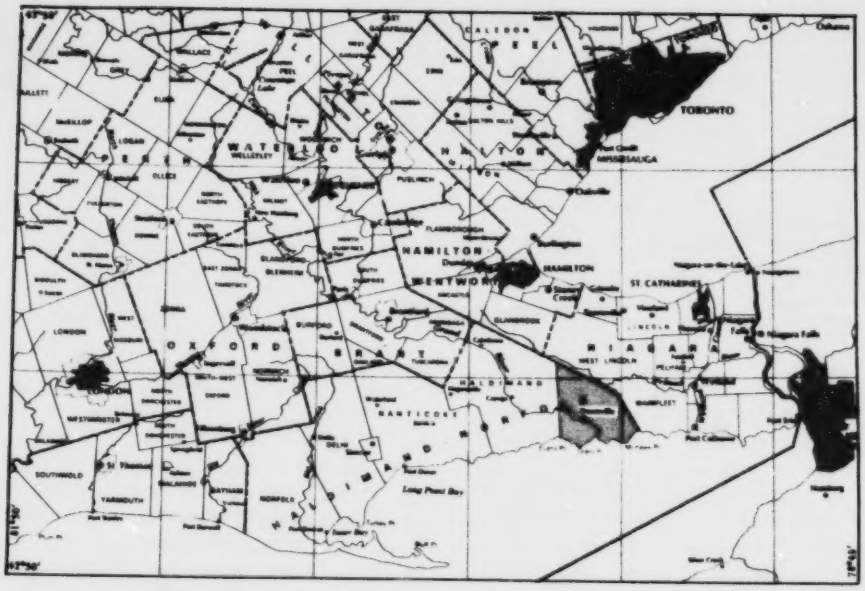

Figure 1 - Key Map Showing the Location of the Town of Dunnville, Scale 1:1 800 000.

This report includes both an inventory and evaluation of sand and gravel as well as bedrock resources in the Town of Dunnville, Regional Municipality of Haldimand-Norfolk. The report is part of the Aggregate Resources Inventory Program for townships and municipalities designated under The Pits and Quarries Control Act, 1971.

The Town of Dunnville has very limited resources of sand and almost no resources of gravel. The existing deposits consist predominantly of fine-grained sand and are generally of limited areal extent. Several deposits, however, have been selected for resource protection at the secondary level of significance. These deposits are capable of meeting some local demands for low-specification construction and road maintenance products.

At present, the Town of Dunnville relies on bedrock-derived aggregate and imported sand and gravel to meet most of its aggregate needs. The town is underlain by bedrock of the Salina, Bertie, Bois Blanc and Onondaga Formations. Of these, the Bertie Formation is best suited for extractive development. Three areas of bedrock have been selected for possible resource protection. An estimated 3200 acres (1300 ha) are currently available for extraction, containing possible resources of 640 million tons (580 million tonnes).

Selected Resource Areas are not intended to be permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

AGGREGATE RESOURCES INVENTORY OF THE TOWN OF DUNNVILLE[1]

BY
STAFF OF THE ENGINEERING
AND TERRAIN GEOLOGY SECTION

INTRODUCTION

Mineral aggregates, which include bedrock-derived crushed stone as well as naturally formed sand and gravel, constitute the major raw material in Ontario's road-building and construction industries. Very large amounts of these materials are used each year throughout the Province. For example, in 1979, the total tonnage of mineral aggregates extracted was 144 million tons (131 million tonnes), greater than that of any other metallic or nonmetallic commodity mined in the Province (Ontario Ministry of Natural Resources 1980).

Although mineral aggregate deposits are plentiful in southern Ontario, they are fixed-location, nonrenewable resources which can be exploited only in those areas where they occur. Mineral aggregates are characterized by their high bulk and low unit value so that the economic value of a deposit is a function of its proximity to a market area as well as its quality and size. The potential for extractive development is usually greatest in urban fringe areas where land use competition is extreme. For these reasons the availability of adequate resources for future development is now being threatened in some areas.

Comprehensive planning and resource management strategies are required to make the best use of available resources, especially in those areas experiencing rapid development. Such strategies must be based on a sound knowledge of the total mineral aggregate resource base at both local and regional levels. The purpose of the Aggregate Resources Inventory is to provide the basic geological information required to include potential mineral aggregate resource areas in planning strategies and official plans. The reports should form the basis for discussion on those areas best suited for possible extraction. The aim is to assist decision-makers in protecting the public well-being by ensuring that adequate resources of mineral aggregate remain available for future use.

This report is a technical background document, based for the most part on geological information and interpretation. It has been designed as a component of the total planning process and should be used in conjunction with other planning considerations, to ensure the best use of a municipality's resources.

The report includes an assessment of sand, gravel and crushed bedrock. The most recent information available has been used to prepare the reports. As new information becomes available, revisions may be necessary.

[1] Manuscript accepted for publication by Chief, Engineering and Terrain Geology Section, July 1, 1984.
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PART I - INVENTORY METHODS

FIELD AND OFFICE METHODS

The methods used to prepare the report primarily involve the interpretation of published geological data such as bedrock and surficial geology maps and reports (see References). Field methods included the examination of natural and man-made exposures of granular material. Most observations were made at quarries and sand and gravel pits located from records held by the Ontario Ministry of Transportation and Communications, the Ontario Geological Survey, and by Regional and District Offices of the Ontario Ministry of Natural Resources. Observations made at pit sites included estimates of the total face height and the proportion of gravel- and sand-sized fragments in the deposit. Observations were also made of the shape and lithology of the particles. These characteristics are important in estimating the quality and quantity of the aggregate. In areas of limited exposure, test pitting, soil probing and hand-augering techniques were used to assess subsurface materials. Airphotos at various scales were used to determine the continuity of deposits, especially in areas of limited subsurface information.

Deposits with potential for further extractive development or those where existing data are scarce, were studied in greater detail. Representative layers in these deposits were sampled in 25- to 100-pound (11 to 45 kg) units either from existing pit faces or from test pits dug by backhoe. The samples were analysed for grain size distribution and in some cases for petrographic assemblage. Analyses were performed by the laboratories of the Soils and Aggregates Section, Engineering Materials Office, Ontario Ministry of Transportation and Communications. In areas of limited subsurface exposure, drilling using a powered hollow stem auger was undertaken. The stratigraphic sections in these test holes are described in drill logs included in the report as Table 7. In some cases samples taken during the course of the drilling were analysed to determine grain size distribution. The symbols for and locations of test hole sites are noted on Map 1.

In the office, the pit and field sample data were supplemented by information on file with the Soils and Aggregates Section of the Ontario Ministry of Transportation and Communications. Data contained in these files include field estimates of the depth, composition and "workability" of deposits as well as laboratory analyses of the physical properties and chemical suitability of the aggregate. Information concerning the development history of the pits and acceptable uses of the aggregate is also recorded. The location, size, and depth of extraction of pits licenced under The Pits and Quarries Control Act, 1971 were obtained from records held by Regional and District Offices of the Ontario Ministry of Natural Resources. The cooperation of the above named groups in the compilation of inventory data is gratefully acknowledged.

Water well records, held by the Ontario Ministry of the Environment, were used in some areas to corroborate thickness estimates, or to indicate the presence of buried granular material. These records were used only in conjunction with other evidence. Soil reports published by the Ontario Ministry of Agriculture and Food were also consulted in order to supply additional information in areas with limited data. Topographic maps of the National Topographic System, at a scale of 1:50 000, were used as a compilation base for the field and office data. The information was then transferred to a township base map, also at a scale of 1:50 000, prepared by the Cartography Section of the Lands and Waters Group, Ontario Ministry of Natural Resources, for presentation in the report.

RESOURCE TONNAGE CALCULATION TECHNIQUES

SAND AND GRAVEL RESOURCES

Once the interpretative boundaries of the aggregate units have been drawn, quantitative estimates of the possible resources available can be made. Generally, the volume of a deposit can be calculated if its areal extent and average thickness are known or can be estimated. The computation methods used are as follows. First, the area of the deposit, as outlined on the final base map, is calculated in acres. The thickness values used are an approximation of the deposit thickness, based on the face heights of pits developed in the deposit or on subsurface data

such as test holes and water well logs. Original tonnage values can then be calculated by multiplying the volume of the deposit by 2500 (the density factor). This factor is approximately the number of tons in a one-foot (0.3 m) thick layer of sand and gravel, one acre (0.4 ha) in extent, assuming an average density of 110 pounds per cubic foot (1766 kg per cubic metre).

Tonnage = Area x Thickness x Density Factor

Tonnage calculated in this manner must be considered only as an estimate. Furthermore, such tonnages represent amounts that existed prior to any extraction of material (i.e. original tonnage) (Table 1, Column 4).

The Selected Sand and Gravel Resource Areas in Table 3 represent only those parts of the deposit lying outside licenced areas (Column 2). Two successive subtractions are made from the unlicenced area. Column 3 accounts for the number of acres unavailable due to the presence of permanent cultural features and their associated setback requirements. Column 4 accounts for those areas lying outside of licenced properties that have previously been extracted (e.g. wayside pits are included in this category). The remaining figure is the area of the deposit currently available for extraction (Column 5). The available area is then multiplied by the estimated deposit thickness and the density factor (Column 5 x Column 6 x 2500) to give an estimate of the sand and gravel tonnage (Column 7) presently available for extractive development and/or resource protection.

BEDROCK RESOURCES

The method used to calculate resources of bedrock-derived aggregate is much the same as that described above. The areal extent of favorable bedrock formations overlain by less than 50 feet (15 m) of unconsolidated overburden is determined from bedrock geology maps, drift thickness and bedrock topography maps and from the interpretation of water well records. The measured extent of such areas is then multiplied by the estimated workable thickness of the formation, based on stratigraphic analyses and on estimates of existing quarry faces in the unit. In some cases a standardized estimate of a workable thickness of 60 feet (18 m) is used. Volume estimates are then multiplied by 3600 (the estimated weight in tons of a one-foot (0.3 m) thick section of dolostone, one acre (0.4 ha) in extent, assuming a bulk density of 165 pounds per cubic foot (2649 kg per cubic metre)).

Resources of sandstone are calculated using a bulk density estimate of 146 pounds per cubic foot (2344 kg per cubic metre) or approximately 3200 tons per acre (7173 tonnes per hectare). Shale resources are calculated on the basis of a bulk density estimate of 150 pounds per cubic foot (2408 kg per cubic metre).

UNITS AND DEFINITIONS

Although most of the measurements and other primary data available for resource tonnage calculations are given in Imperial units, Metric units have also been given in the text and on the tables which accompany the report. The Metric equivalent of the data is shown in brackets after or directly below the corresponding Imperial figures. Data are generally rounded off in accordance with the Ontario Metric Practice Guide (Metric Committee 1975).

The tonnage estimates made for sand and gravel as well as bedrock-derived aggregates are termed possible resources in accordance with terminology of the Ontario Resource Classification Scheme (Robertson 1975, p. 7) and with the Association of Professional Engineers of Ontario (1976) (see Glossary, Appendix B).

PART II - DATA PRESENTATION AND INTERPRETATION

Three maps, each portraying a different aspect of the aggregate resources in the municipality, accompany the report. Map 1, "Distribution of Sand and Gravel Deposits", gives a comprehensive inventory of the sand and gravel resources in the report area. Map 2, "Selected Sand and Gravel Resource Areas", shows those deposits which are considered to represent the largest and/or highest quality resources in the area. Map 3, "Bedrock Resources", shows the distribution of bedrock formations, the thickness of overlying unconsolidated sediments, and identifies the Selected Bedrock Resource Areas.

MAP 1: DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

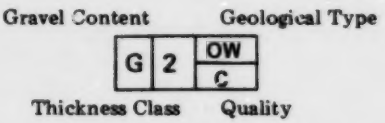
Map 1 is derived directly from the existing surficial geology maps of the area or from airphoto and field interpretation where surficial mapping is incomplete. It shows the extent and quality of sand and gravel deposits within the study area and the present level of extractive activity.

The present level of extractive activity in the study area is indicated as follows. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the pit descriptions in Table 2. Each description notes the owner, location and licenced acreage of the pit, as well as the estimated face height and percentage gravel. A number of unlicenced pits (abandoned pits or wayside pits operating on demand under authority of a permit) are also identified and numbered on Map 1 and described in Table 2.

Map 1 also presents a summary of available information related to the quality of aggregate contained in all the known aggregate deposits in the study area. Much of this information is contained in the symbols which are found on the map. The Deposit Symbol appears for each mapped deposit and summarizes important genetic and textural data. The Texture Symbol is a circular proportional diagram which displays the grain size distribution of the aggregate in areas where bulk samples were taken.

DEPOSIT SYMBOL

The Deposit Symbol is similar to those used in soil mapping and land classification systems commonly in use in North America. The components of the symbol indicate the gravel content, thickness of material, origin (type), and quality limitations for a given deposit. These components are illustrated by the following example:



This symbol identifies an outwash deposit 10 to 20 feet (3 to 6 m) thick containing more than 35 percent gravel. Excess silt and clay may limit uses of the aggregate in the deposit.

The "gravel content" and "thickness class" are basic criteria for distinguishing different deposits. The "gravel content" symbol is an upper case "S" or "G". The "S" indicates that the deposit is generally "sandy" and that gravel-sized aggregate (greater than 4.75 mm) makes up less than 35 percent of the whole deposit. "G" indicates that the aggregate probably contains more than 35 percent gravel.

The "thickness class" indicates a depth range which is related to the potential resource tonnage for each deposit. Four thickness class divisions have been established as shown in the legend for Map 1.

Two smaller sets of letters, divided from each other by a horizontal line, follow the thickness class number. The upper series of letters identify the geologic deposit type (the types are summarized with respect to their main geologic and extractive characteristics in Appendix C) and the lower series of letters identify the main quality limitations that may be present in the deposit, as discussed in the next section.

TEXTURE SYMBOL

The Texture Symbol provides a more detailed assessment of the grain size distribution in deposits where samples were taken for analysis during field study. The data from which these symbols are derived has been plotted on grain size distribution graphs. The relative amounts of gravel, sand, silt, and clay in the sampled material are shown graphically by the sub-

division of a circle into proportional segments. The following example shows a hypothetical sample consisting of 30 percent gravel, 60 percent sand, and 10 percent silt and clay:

Test hole locations are shown on Map 1 by a solid drill hole symbol.

MAP 2: SELECTED SAND AND GRAVEL RESOURCE AREAS

Map 2 is an interpretative map derived from an evaluation of the deposits shown on Map 1. The deposits identified on Map 2 are those which are considered to be important in ensuring an adequate resource base for the future.

All the selected sand and gravel resource areas are first delineated by geological boundaries and then classified into three levels of significance: primary; secondary; and tertiary. These areas are identified on Map 2 by different shading patterns. Each area of primary significance is assessed as to its probable relative value as a resource in the municipality and is given a deposit number which denotes its ranking order. All such deposits are shown by a dark shading on Map 2.

Selected Sand and Gravel Resource Areas of primary significance are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major resource is known to exist. Such Resource Areas may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

Deposits of secondary significance are not ranked numerically in this report, but are indicated by a light shading on Map 2. Such deposits are believed to contain significant amounts of sand and gravel. Although deposits of secondary significance are not considered to be the "best" resource areas in a municipality, they may contain large quantities of sand and gravel and should be considered an integral component of the aggregate supply of the municipality.

Areas of tertiary significance are indicated on the map by a dashed line but have no shading. They are neither rated nor considered to be important resource areas because of their low available resources, or because of possible difficulties in extraction. Such areas may be useful for local needs but are unlikely to support large-scale development.

The process by which deposits are evaluated and selected involves the consideration of two sets of criteria. The main selection criteria are site specific, related to the characteristics of individual deposits. Factors such as deposit size, aggregate quality, and deposit location and setting are considered in the selection of those deposits best suited for extractive development. A second set of criteria involves the assessment of local aggregate resources in relation to the quality, quantity, and distribution of resources in the region in which the municipality is located. The intent of such a process of evaluation is to ensure the continuing availability of sufficient resources to meet possible future demands.

SITE SPECIFIC CRITERIA

DEPOSIT SIZE

Ideally, selected deposits should contain available sand and gravel resources large enough to support a commercial pit operation using a stationary or portable processing plant. In practice, much smaller deposits may be of significant value depending on the overall reserves in the rest of the municipality. Generally, deposits in Class 1, i.e. those thicker than 20 feet (6m) and containing more than 35 percent crushable gravel are considered to be most favourable for commercial development. Thinner deposits may be valuable in municipalities with low total resources.

AGGREGATE QUALITY

The limitations of natural aggregates for various uses result from variations in the lithology of the particles composing the deposit, and from variations in the size distribution of these particles.

Four indicators of the quality of aggregate may be included in the symbol for each deposit on Map 1. They are: gravel content (G or S); fines (C); oversize (O); and lithology (L).

Three of the indicators deal with grain size distribution. The gravel content (G or S) indi-

cates the suitability of aggregate for various uses. Deposits containing at least 35 percent gravel in addition to a minimum of 20 percent material greater than the 26.5 mm sieve are considered to be the most favourable extractive sites, since this content is the minimum from which crushed products can be economically produced.

Excess fines (or high silt and clay content) may severely limit the potential use of an aggregate. Fines content in excess of 10 percent may impede drainage in road sub-base aggregate and render it more susceptible to the effects of frost action. In asphaltic aggregate, excess fines hinder the bonding of particles. Deposits known to have a high fines content are indicated by a "C" in the quality portion of the Deposit Symbol.

Deposits containing more than 20 percent oversize material (greater than 4 inches (10 cm) in diameter) may also have use limitations. The oversize component is unacceptable for all concrete aggregate and for road-building aggregate, so it must be either crushed or removed during processing. Deposits known to have an appreciable oversize component are indicated by an "O" in the quality portion of the Deposit Symbol.

The other indicator of the quality of an aggregate is lithology. Just as the unique physical and chemical properties of bedrock formations determine their value for use as crushed rock, so do various lithologies of particles in a sand and gravel deposit determine its suitability for various uses. The presence of objectionable lithologies such as chert, siltstone, and shale, even in relatively small amounts, can result in a reduction in the quality of an aggregate, especially for high-quality uses such as concrete or structures. Deposits known to contain objectionable lithologies are indicated by an "L" in the quality component of the Deposit Symbol.

If the Deposit Symbol indicates either "C", "O", or "L" or any combination, the quality of the deposit is considered to be reduced for some uses of the aggregate. No attempt has been made to quantify the degree of limitation imposed. Assessment of the four indicators is made from published data, from data contained in files of the Ontario Ministry of Transportation and Communications and the Engineering and Terrain Geology Section of the Ontario Geological Survey, and from field observations. The Engineering Materials Office of the Ontario Ministry of Transportation and Communications has recently compiled a detailed assessment of aggregate suitability for selected areas in southern Ontario. This material has been consulted extensively in preparation of the inventory reports.

Analyses of unprocessed samples obtained from test holes and pits have been plotted on grain size distribution graphs. On the graphs are the gradation specification envelopes for Ontario Ministry of Transportation and Communications' products — Granular Base Course A,B, and C; and Hot-Laid Asphaltic Sand Nos. 1, 2, 3, 4, 5, 6 and 8. By plotting the gradation curves with respect to the specification envelopes, it can be determined how well the unprocessed sampled material meets the criteria for each product.

LOCATION AND SETTING

The location and setting of a resource area has a direct influence on its value for possible extraction. The evaluation of a deposit's setting is made on the basis of those natural and man-made features which may limit or prohibit extractive development.

First, the physical context of the deposit is considered. Deposits with some physical constraint on extractive development, such as thick overburden or high water table, are less valuable resource areas because of the difficulties involved in resource recovery. Second, permanent man-made features, such as roads, railways, power lines, and housing developments, which are built on a deposit, may prohibit its extraction. The constraining effect of legally required setbacks surrounding such features is included in the evaluation. A quantitative assessment of these constraints can be made by measurement of their areal extent directly from the topographic maps. The area rendered unavailable by these features is shown for each resource area in Table 3 (Column 3).

The assessment of sand and gravel deposits and bedrock resource areas with respect to local land use and to private land ownership is an important component of the general evaluation process. These aspects of the evaluation process are not considered further in this report but

readers are encouraged to discuss them with personnel of the pertinent District Office of the Ontario Ministry of Natural Resources.

REGIONAL CONSIDERATIONS

In selecting sufficient areas for resource development, it is important to assess both the local and the regional resource base, and to forecast future production and demand patterns.

Some appreciation of future aggregate requirements in an area may be gained by assessing its present production levels and by forecasting future production trends. Such an approach is based on the assumptions that production levels in an area closely reflect the demand and that the present production "market share" of an area will remain at roughly the same level.

The aggregate resources in the region surrounding a municipality should be assessed in order to properly evaluate specific resource areas and to adopt optimum resource management plans. For example, a municipality that has large resources in comparison to its surrounding region constitutes a regionally significant resource area. Municipalities with high resources in proximity to large demand centres, such as metropolitan areas, are special cases.

Although an appreciation of the regional context is required to develop comprehensive resource management techniques, such detailed evaluation is beyond the scope of this report. The selection of resource areas made in this study is based primarily on geological data or on considerations outlined in preceding sections.

MAP 3: BEDROCK RESOURCES

Map 3 is an interpretative map derived from bedrock geology, bedrock topography, drift thickness maps, water well data from the Ontario Ministry of the Environment, oil and gas well data from the Petroleum Resources Section (Ontario Ministry of Natural Resources), and from geotechnical test hole data from various sources. Map 3 is based on concepts similar to those outlined for Maps 1 and 2, but displays both the inventory and evaluation on the one map.

The geological boundaries of the bedrock units are shown by a dashed line. Isolated outcrops are indicated by an "X". Three sets of contour lines delineate areas of less than 3 feet (1 m) of drift, areas of 3 to 25 feet (1 to 8 m) of drift, and areas of 25 to 50 feet (8 to 15 m) of drift. The extent of the areas of thin drift are shown by three shades. The darkest shade indicates areas where bedrock outcrops or is within 3 feet (1 m) of the ground surface. These areas constitute potential resource areas of primary significance because of their easy access. The medium shade indicates areas where drift cover is up to 25 feet (8 m) thick. Quarrying is possible in this depth of overburden and these also represent potential resource areas. The lightest shade indicates bedrock areas overlain by 25 to 50 feet (8 to 15 m) of overburden. These latter areas constitute resources which have extractive value only in specific circumstances. Outside of these delineated areas the bedrock can be assumed to be covered by more than 50 feet (15 m) of overburden, a depth generally considered to be too great to allow economic extraction (unless part of the overburden is composed of economically attractive sand and gravel deposits).

Other inventory information presented on Map 3 is designed to give an indication of the present level of extractive activity in the municipality. Those areas which are licenced for extraction under The Pits and Quarries Control Act, 1971 are shown by a solid outline and identified by a number which refers to the quarry descriptions in Table 5. Each description notes the owner, location, and licenced acreage of the quarry and an estimate of face height. Unlicenced quarries (abandoned quarries or wayside quarries operating on demand under authority of a permit) are also identified and numbered on Map 3 and described in Table 5. One additional symbol appears on the map: an open dot indicates the location of a selected well which penetrates bedrock. The overburden thickness is shown in feet beside the open dot.

SELECTION CRITERIA

Criteria equivalent to those used for sand and gravel deposits are used to select bedrock areas most favourable for extractive development.

The evaluation of bedrock resources is made primarily on the basis of performance and suitability data established by laboratory testing at the Ontario Ministry of Transportation and

Communications. The main characteristics and uses of the bedrock formations found in southern Ontario are summarized in Appendix D.

Deposit "size" is related directly to the areal extent of thin drift cover overlying favourable bedrock formations of sufficient thickness to support quarry operations. Since vertical and lateral variations in bedrock units are much more gradual than in sand and gravel deposits, the quality and quantity of the resource is usually consistent over large areas.

Quality of the aggregate derived from specific bedrock units is established by the performance standards previously mentioned. Location and setting criteria and regional considerations are identical to those for sand and gravel deposits.

SELECTED RESOURCE AREAS

Selection of Bedrock Resource Areas has been restricted to a single level of significance. Three factors support this approach. First, quality and quantity variations are gradual. Second, the areal extent of a given quarry operation is much smaller than that of a sand and gravel pit producing an equivalent tonnage of material, and third, since crushed bedrock has a higher unit value than sand and gravel, longer haul distances can be considered. These factors allow the identification of alternative sites having similar development potential. The Selected Areas are shown on Map 3 by a line pattern and the calculated available tonnages are given in Table 6.

Selected Bedrock Resource Areas shown on Map 3 are not permanent, single land use units which must be incorporated in an official planning document. They represent areas in which a major bedrock resource is known to exist. Such a resource area may be reserved wholly or partially for extractive development and/or resource protection within the context of the official plan.

PART III - ASSESSMENT OF AGGREGATE RESOURCES IN THE TOWN OF DUNNVILLE

LOCATION AND POPULATION

The Town of Dunnville occupies an area of 72,866 acres (29 489 ha) in the easternmost part of the Regional Municipality of Haldimand-Norfolk. The town was formed during the incorporation of the regional municipality in 1974, and includes the former townships of Canboro, Dunn, Moulton and Sherbrooke. Dunnville is shown on parts of the Dunnville (30 L/13), Grimsby (30 M/4) and Welland (30 L/14) map sheets of the National Topographic System at a scale of 1:50 000.

The population of the Town of Dunnville was 11 226 in 1982 and its population has increased 2 percent since 1973 (Ontario Ministry of Municipal Affairs and Housing 1983; Ontario Ministry of Treasury, Economics and Intergovernmental Affairs 1974). The community of Dunnville, which is located along the northern bank of the Grand River, is the major population centre in the town. Other smaller settlements include Canboro, Byng and Port Maitland. Outside these communities, the majority of the residents are engaged in farming, although there is a number of rural-residential inhabitants and a large recreational population along the shore of Lake Erie. Rock Point Provincial Park is a major recreational centre in the town.

Access within the town is provided by King's Highway 3 and a number of township roads and paved regional roads. Dunnville is also served by lines of the Canadian National, Conrail, and the Toronto, Hamilton and Buffalo Railways.

PHYSIOGRAPHY AND SURFICIAL GEOLOGY

The physiography and distribution of unconsolidated sediments, including the sand and gravel deposits, are predominantly the result of glacial activity. This activity took place during the Late Wisconsinan Substage of the Pleistocene Epoch, informally known as the 'Great Ice Age'. This substage, which lasted from approximately 23 000 to 10 000 years ago was marked by the repeated advance and melting back of massive, continental ice sheets.

The oldest glacial sediment present in the area is the Wentworth Till (Feenstra 1974). It was deposited by the Ontario-Erie glacial lobe which advanced in a southwesterly direction (Feenstra 1974, 1981). This gravelly silt till, for the most part, is covered by younger glaciolacustrine sediments and is exposed at the ground surface only in three drumlins located in the northern corner of the town. The younger Halton Till was deposited after the Wentworth Till and is also generally covered by lacustrine sediments. The clay to clayey silt Halton Till is exposed north of the Lake Erie shore in the southwestern part of the town and in bluffs along Mohawk Bay, where it forms the Mohawk Bay Moraine (Feenstra 1981). The moraine is believed to be a recessional moraine formed during a temporary halt of the melting ice sheet. These tills are of little value as aggregate because of their high silt and clay content.

As the ice retreated, a series of proglacial lakes covered the area. In the deep waters of these lakes, glaciolacustrine silt and clay were deposited. This material is the predominant surficial sediment in the Niagara peninsula, between Lake Erie and the Niagara Escarpment, and forms the physiographic region known as the Haldimand Clay Plain (Chapman and Putnam 1966).

As the water levels lowered, an increasing amount of land was exposed in the west. The ancestral Grand River flowed into the shallow western part of the glacial lake near Dunnville, depositing sand in a broad delta (Feenstra 1974, 1981). The delta consists largely of fine-grained sand and silt, although some coarse sand was deposited near the community of Dunnville. Beach sand and gravel was also deposited during the lowering of lake levels. Two small beach deposits exist in the town. One was deposited on the Mohawk Bay Moraine and the other near Mohawk Point.

After the water in the lakes drained, the deltaic sands became susceptible to postglacial wind erosion and transport. Deposition of eolian sand occurred mainly in the form of parabolic dunes (Feenstra 1974, 1981). Both the dune sand and, to a lesser extent, the glaciolacustrine sand have been utilized for aggregate in the Town of Dunnville.

Postglacial activity has also resulted in the deposition of alluvium along the banks of the

Grand River and the tributaries of the Welland River, along with the recent development of beaches and dunes along Lake Erie.

EXTRACTIVE ACTIVITY

A number of sand pits have been opened in the Town of Dunnville. The majority are located in sand dunes in the east-central part of the town. At the time of writing, five pits were licenced to operate, occupying an area of 250.0 acres (101.2 ha). One quarry, with an area of 109.0 acres (44.1 ha) is licenced to extract bedrock in the southern part of the town.

The Town of Dunnville was designated in 1974 under The Pits and Quarries Control Act, 1971. Since the designation of the town, production figures for the licenced properties have been maintained by the Fonthill District Office of the Ontario Ministry of Natural Resources. The average annual production from both pits and quarries in the seven-year period between 1974 and 1980 has been approximately 263,000 tones (239 000 tonnes).

Since the Town of Dunnville has a limited supply of quality sand and almost no gravel, it relies on bedrock-derived aggregate to meet most of its needs. In addition, concrete aggregate is imported into the town. However, the town has existing resources of sand capable of meeting some of the local demands for low-specification construction products such as fill. The sand is generally unsuitable for high-specification uses such as asphalt and concrete.

SELECTED SAND AND GRAVEL RESOURCE AREAS

Several sand deposits have been selected for possible resource protection at the secondary level of significance. Since the sand and gravel deposits in the town are capable of supplying aggregate suitable for only a restricted range of low-specification products, and are generally of limited areal extent, no deposits have been selected at the primary level of significance.

Many of the larger sand dunes situated in the east-central part of the town have been selected for possible resource protection at the secondary level of significance. The dunes consist of uniform, fine-grained sand. Samples of the sand, taken from pit nos. 1 and 11, revealed a silt content of 5 to 9 percent, respectively (Figure 2a). Five licenced properties and at least ten unlicenced pits have been developed in the dunes with pit faces ranging from 2 to 20 feet (0.6 to 6 m) high. The material extracted from the pits is generally suitable for granular borrow and acceptable to borderline for Granular Base Course C. The material may also be suitable for blending sand if the fines content is reduced. The licenced sources are primarily small operations supplying aggregate for local use.

Additional resources of sand and gravel may be buried beneath clay in the area. Faces in pit no. 14 exposed 5 to 7 feet (1.5 to 2 m) of clay over 13 feet (4 m) of interbedded sand and gravel (B.H. Feenstra, Mineral Resources Geologist, Ontario Ministry of Natural Resources, London, personal communication, 1982). Samples of the aggregate contained between 4 and 45 percent gravel and size analysis performed on the material indicates the aggregate may be suitable for some granular base course products (Figure 3). Other than this pit exposure, information pertaining to buried granular deposits in the town is lacking and additional subsurface investigation is required to locate sites suitable for possible extractive development.

BEDROCK GEOLOGY

The Town of Dunnville is underlain by the Upper Silurian bedrock of the Salina and Bertie Formations as well as by the Lower to Middle Devonian bedrock of the Bois Blanc Formation and the Middle Devonian Onondaga Formation. Drift overlying the bedrock is generally thinnest in the southern part of the town, near Lake Erie. A number of quarries have been developed in this area and bedrock is exposed in several outcrops which are especially abundant along the shore of Lake Erie.

The Salina Formation underlies the northern part of the town and consists of argillaceous dolostone and shale with lenses of gypsum and other evaporitic materials (Telford and Tarrant 1975a, b). The formation has been mined for gypsum in the eastern part of the Town of Haldimand, but has little value as aggregate.

South of the Grand River, an east-west trending bedrock ridge known as the Onondaga Escarpment is a prominent physiographic feature. It was produced by the resistant dolo-

stones of the Bertie Formation. Telford and Tarrant (1975a) have described four units which make up the formation in the area. The lowermost unit consists of at least 13 feet (4 m) of thick-bedded, bituminous dolostone which is overlain by 6 to 8 feet (2 m) of very argillaceous dolostone. This in turn is overlain by 3.5 to 10 feet (1.1 to 3 m) of mottled, fine-grained dolostone. The uppermost unit consists of at least 17 feet (5 m) of very fine-grained dolostone with bituminous laminations. The formation is suitable for the production of a range of construction and road-building products. However, the very argillaceous dolostone may be unsuitable for some aggregate uses because of poor durability (Hewitt 1960).

The Bertie Formation is overlain by the limestones of the Bois Blanc and Onondaga Formations. The Bois Blanc strata consist of brownish grey, medium- to thin-bedded cherty limestone. The formation is commonly fossiliferous and contains shale partings and minor dolostone. At the base of the formation a sandstone unit up to 6 feet (2 m) thick is often present (Telford and Tarrant 1975a). The youngest bedrock in the town is the Onondaga Formation. It is a medium-bedded, fine- to medium-grained, fossiliferous, cherty limestone. Both the Bois Blanc and Onondaga Formations have been quarried for crushed stone, but their high chert content makes much of the material unsuitable for concrete aggregate. The Onondaga Formation was once used as a raw material in cement manufacture. A licenced quarry in the neighbouring Township of Wainfleet extracted the limestone for this purpose.

SELECTED BEDROCK RESOURCE AREAS

Three areas have been selected for possible bedrock resource protection in the Town of Dunnville. They are located in the southwestern part of the town. The bedrock in these areas is overlain by less than 25 feet (8 m) of overburden and includes the Bertie, Bois Blanc and Onondaga Formations. Of these, the chert-free Bertie dolostone is considered the most desirable for extractive development as a wider range of products can be produced. The Bois Blanc Formation and part of the Onondaga Formation have been selected primarily on the basis of the availability of the underlying Bertie dolostone for extraction.

The Selected Bedrock Resource Areas occupy a total available area of 3200 acres (1300 ha) and contain resources of approximately 640 million tons (580 million tonnes). The areas are readily accessible by road and are located near rail transportation.

SELECTED BEDROCK RESOURCE AREA 1

Selected Bedrock Resource Area 1 consists of two areas, labelled 1a and 1b on Map 3. The bedrock consists of Bertie dolostone which is overlain by less than 25 feet (8 m) of drift. Three quarries have been developed in the Resource Area. Only quarry no. 1 is presently licenced.

Quarry no. 1, operated by Dunnville Rock Products Limited, is the major producer of aggregate in the town. Faces in the quarry range in height from 37 to 42 feet (11 to 13 m) and expose predominantly Bertie dolostone. Nine feet (3 m) of the Bois Blanc Formation overlie the Bertie in the southern part of the quarry where it extends into Resource Area 2. Nine different grades of stone are produced from the quarry and they are used largely for granular base course and concrete. Other secondary products are winter sand from crusher screenings and armour stone. The Ontario Ministry of Transportation and Communications report that aggregate extracted from the quarry is only marginally suitable for hot-laid asphaltic use. In the northeast corner of the quarry, approximately 8 feet (2 m) of very argillaceous dolostone is exposed. This argillaceous material may be unsuitable for some aggregate uses.

Resource Area 1 occupies 610 acres (247 ha), exclusive of the licenced area. Cultural constraints and previous extraction reduce the area currently available to 450 acres (182 ha). Assuming a workable thickness of 40 feet (12 m), available bedrock resources are estimated to total 65 million tons (59 million tonnes).

SELECTED BEDROCK RESOURCE AREA 2

Two areas, labelled 2a and 2b on Map 3, make up Selected Bedrock Resource Area 2. The bedrock in Area 2 is covered by less than 25 feet (8 m) of drift and consists of both the Bois Blanc limestone and the underlying Bertie Formation. Since the Bois Blanc strata average only 15 feet (5 m), it is possible to also extract the underlying Bertie Formation, resulting in a 55-foot (17 m) workable thickness estimate.

Only the southernmost faces of quarry no. 1 extend into the Resource Area, and these faces are worked primarily for the Bertie dolostone. The cherty Bois Blanc Formation is usually stripped off and used for work on the licenced property itself. However, the Bois Blanc Formation has been utilized as crushed stone for granular base course and railway ballast elsewhere in southern Ontario.

Selected Resource Area 2 occupies 1420 acres (580 ha), exclusive of the licenced area. An estimated 1160 acres (470 ha) are currently available for extraction, containing bedrock resources of approximately 230 million tons (209 million tonnes).

SELECTED BEDROCK RESOURCE AREA 3

Selected Bedrock Resource Area 3 is made up of two areas, designated 3a and 3b on Map 3. The bedrock surface in Area 3 consists of the Onondaga limestone which is overlain by less than 25 feet (8 m) of drift. Since the Onondaga Formation thins in a northerly direction and the underlying Bois Blanc limestone averages only 15 feet (5 m) in thickness, it is also possible to extract part of the Bertie dolostone in the area near the Onondaga-Bois Blanc contact. For this reason, the southern boundary of Area 3a is marked by a geological thickness boundary. The boundary denotes the approximate point where the Onondaga and Bois Blanc Formations reach a combined thickness of 30 feet (9 m). North of this boundary it is considered economically viable to extract the high quality Bertie dolostone along with the overlying Onondaga and Bois Blanc strata.

The Onondaga and Bois Blanc limestones in Area 3 are generally suitable for use as granular base course and railway ballast. However, the high chert content of the rocks prevents them from being used for higher specification products such as concrete aggregate. Higher quality rock, in Area 3, is available from the Bertie Formation which is suitable for higher specification products such as concrete stone. Only one quarry has been developed in the Area. Faces in the quarry range from 10 to 15 feet (3 to 5 m) and expose cherty, very fossiliferous limestone.

Resource Area 3 totals 2000 acres (810 ha), exclusive of the licenced area. Cultural constraints and previous extraction reduce the area presently available to 1600 acres (650 ha). Assuming a workable thickness of 60 feet (18 m), available bedrock resources are estimated to be 345 million tons (315 million tonnes).

SUMMARY

The sand and gravel deposits of the Town of Dunnville are the product of glacial activity and the postglacial deposition of dune sand and alluvium. Several sand dunes have been selected at the secondary level of significance. These deposits contain only limited resources of fine sand. However, the existing resources are capable of meeting some of the local demands for low-specification construction products.

Since the town has a limited supply of sand and almost no gravel, it relies on bedrock-derived aggregate to meet most of its needs. Concrete aggregate is also imported into the town. Three areas in the town have been selected for possible bedrock resource protection. The bedrock in these areas consists of the Bertie, Bois Blanc and Onondaga Formations. Only the Bertie Formation is capable of supplying a range of high-specificaton aggregate products. Stone from the Bois Blanc and Onondaga Formations is suited only for granular base course and low-specification products.

Enquiries regarding the Aggregate Resources Inventory for the Town of Dunnville should be directed to the Ontario Ministry of Natural Resources, either at the Niagara District Office, Highway 20, Box 1070, Fonthill, Ontario, L0S 1E0 (Tel. (416) 892-2656) or at the Central Region Office, 10670 Yonge Street, Richmond Hill, Ontario, L4C 3C9 (Tel. (416) 884-9203).

TABLE 1 | TOTAL SAND AND GRAVEL RESOURCES, TOWN OF DUNNVILLE

1 CLASS NO.	2 DEPOSIT TYPE (see Appendix C)	3 AREAL EXTENT Acres (Hectares)	4 ORIGINAL TONNAGE Millions of Tons (Tonnes)
2	S-WD	600 (243)	16 (14)
3	G-LB	25 (10)	1 (1)
	S-LD	19,300 (7800)	265 (240)
	S-LP	340 (138)	5 (4)
	S-WD	1320 (530)	30 (27)
4	S-AL	600 (243)	5 (4)
	S-LP	590 (239)	4 (4)
		22,800 (9200)	325 (295)

N.B. Minor variations in all tables are caused by rounding of data.

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF DUNNVILLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
LICENCED PITS							
1	–	R. Plath	1, 2	3	19.0 (7.7)	3-5 (1-1.5)	sand
2	–	R. Egger	2	N.F.R.	5.0 (2.0)	rehabilitated	
3	–	W. Lovesgrove	19	2 R.G.R.	37.0 (15.0)	4-12 (1.2-4)	sand
4	–	J. Gibson	20	1, 2 R.G.R.	139.0 (56.2)	overgrown	
5	–	G. Barnes & Sons Ltd.	4, 5	4 Cross	50.0 (20.2)	2-3 (0.6-1)	sand partially rehabilitated
					250.0 (101.2)		
UNLICENCED PITS*							
6	D5-15	J. Huffman	2	3	–		rehabilitated
7	–	Unknown	3	3	–	3 (1)	sand
8	–	Unknown	9	Gore B	–	5-15 (1.5-5)	sand
9	D5-19	Unknown	8, 9	Gore B	–	5-15 (1.5-5)	sand
10	–	Unknown	9	Gore B	–	3 (1)	sand
11	–	Unknown	13	S.F.R.	–	10 (3)	sand
12	–	Unknown	9	3	–	10 (3)	sand
13	W3-14	W.R. Huffman	1	S.F.R.	–	5 (1.5)	sand

TABLE 2 | SAND AND GRAVEL PITS, TOWN OF DUNNVILLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREAS Acres (Hectares)	7 FACE HEIGHT Feet (Metres)	8 % GRAVEL
14	–	Unknown	2	4	–	15-20 (5-6)	4-45 (buried)
15	–	Unknown	10	1	–	14-18 (4-6)	sand over till

* Abandoned pits.

TABLE 3 | SELECTED SAND AND GRAVEL RESOURCE AREAS, TOWN OF DUNNVILLE

1 **DEPOSIT NO.**	2 **UNLICENCED AREA** Acres (Hectares)	3 **CULTURAL SETBACKS** Acres (Hectares)	4 **EXTRACTED AREA** Acres (Hectares)	5 **AVAILABLE AREA** Acres (Hectares)	6 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	7 **AVAILABLE AGGREGATE** Millions of Tons (Tonnes)

– NONE –

TABLE 4 | TOTAL IDENTIFIED BEDROCK RESOURCES, TOWN OF DUNNVILLE

1 **DRIFT THICKNESS** Feet (Metres)	2 **FORMATION**	3 **ESTIMATED DEPOSIT THICKNESS** Feet (Metres)	4 **AREAL EXTENT** Acres (Hectares)	5 **ORIGINAL TONNAGE** Millions of Tons (Tonnes)
0-3 (0-1)	Onondaga Formation	35 (11)	44 (18)	6 (5)
3-25 (1-8)	Onondaga Formation	35 (11)	5500 (2230)	690 (630)
25-50 (8-15)	Onondaga Formation	35 (11)	2600 (1050)	330 (300)
			8100 (3300)	1030 (930)
0-3 (0-1)	Bois Blanc Formation	15 (5)	16 (6)	1 (1)
3-25 (1-8)	Bois Blanc Formation	15 (5)	1790 (720)	97 (88)
25-50 (8-15)	Bois Blanc Formation	15 (5)	1560 (630)	84 (76)
			3350 (1360)	182 (165)
0-3 (0-1)	Bertie Formation	40 (12)	12 (5)	2 (2)
3-25 (1-8)	Bertie Formation	40 (12)	660 (265)	95 (86)
25-50 (8-15)	Bertie Formation	40 (12)	1730 (700)	249 (226)
			2400 (970)	345 (315)
25-50 (8-15)	Salina Formation	60 (18)	1580 (640)	315 (285)
			15,400 (6200)	1870 (1700)

TABLE 5 | QUARRIES, TOWN OF DUNNVILLE

1 NO.	2 MTC NO.	3 OWNER/OPERATOR	4 LOT	5 CON.	6 LICENCED AREA Acres (Hectares)	7 FACE HEIGHT Feet (Metres)
LICENCED QUARRIES						
1	D5-5	Dunnville Rock Products Ltd.	Parts of 3, 6, 7, 8	Earl Tract	109.0 (44.1)	37-42 (11-13)
UNLICENCED QUARRIES*						
2	D5-9	Onondaga Quarry	5	1N	–	10-15 (3-5)
3	D5-8	Webber	22	Haldimand Tract	–	20-25 (6-8)
4	–	Unknown	10	2	–	15 water (5) filled
5	D5-22	Smively Quarry	2	3	–	10-20 (3-6)

* Abandoned quarries.

TABLE 6 | SELECTED BEDROCK RESOURCE AREAS, TOWN OF DUNNVILLE

1 DEPOSIT NO.	2 DEPTH OF OVERBURDEN Feet (Metres)	3 UNLICENCED AREA Acres (Hectares)	4 CULTURAL SETBACKS Acres (Hectares)	5 EXTRACTED AREA Acres (Hectares)	6 AVAILABLE AREA Acres (Hectares)	7 ESTIMATED WORKABLE THICKNESS Feet (Metres)	8 AVAILABLE RESOURCES Millions of Tons (Tonnes)
1a	3-25 (1-8)	570 (231)	150 (61)	5 (2)	415 (168)	40 (12)	60 (54)
1b	3-25 (1-8)	40 (16)	5 (2)	0 (0)	35 (14)	40 (12)	5 (4)
		610 (247)	155 (63)	5 (2)	450 (182)		65 (59)
2a	3-25 (1-8)	1280 (520)	230 (93)	0 (0)	1050 (425)	55* (17)	208 (189)
2b	0-25 (0-8)	140 (57)	30 (12)	0 (0)	110 (44)	55 (17)	22 (20)
		1420 (580)	260 (105)	0 (0)	1160 (470)		230 (209)
3a	3-25 (1-8)	1900 (770)	350 (142)	0 (0)	1550 (630)	60** (18)	335 (305)
3b	0-25 (0-8)	105 (42)	40 (16)	15 (6)	50 (20)	60 (18)	11 (10)
		2000 (810)	390 (158)	15 (6)	1600 (650)		345 (315)
		4050 (1640)	805 (325)	20 (8)	3200 (1300)		640 (580)

* Quarriable thickness in Resource Area 2 consists of 15 feet (5 m) of Bois Blanc Formation overlying 40 feet (12 m) of Bertie Formation.

** Quarriable thickness in Resource Area 3 includes the Onondaga and Bois Blanc Formations along with part of the underlying Bertie Formation.

TABLE 7 | SUMMARY OF TEST HOLE DATA, TOWN OF DUNNVILLE

– NONE –

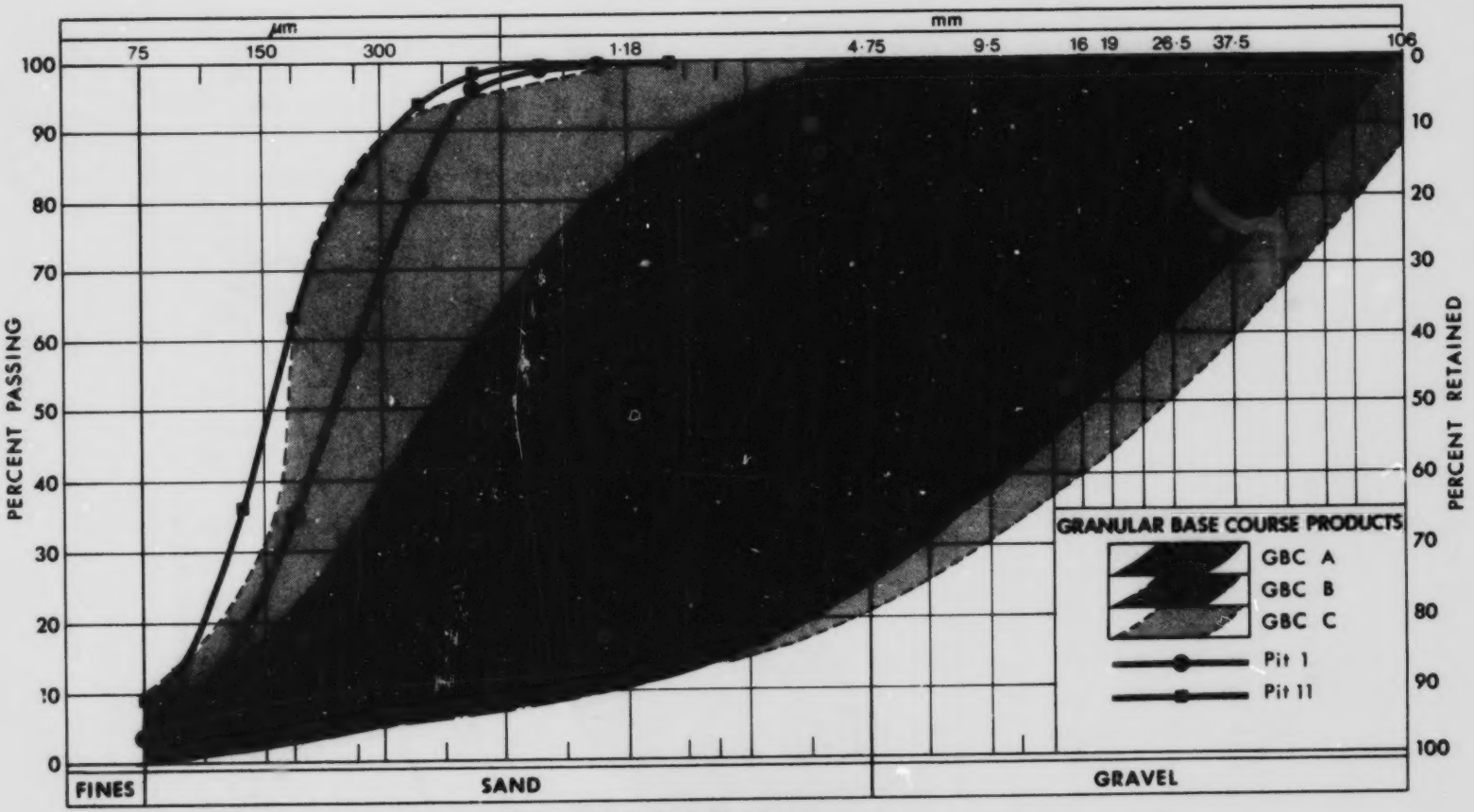


FIGURE 2a: AGGREGATE GRADING CURVES, TOWN OF DUNNVILLE;

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

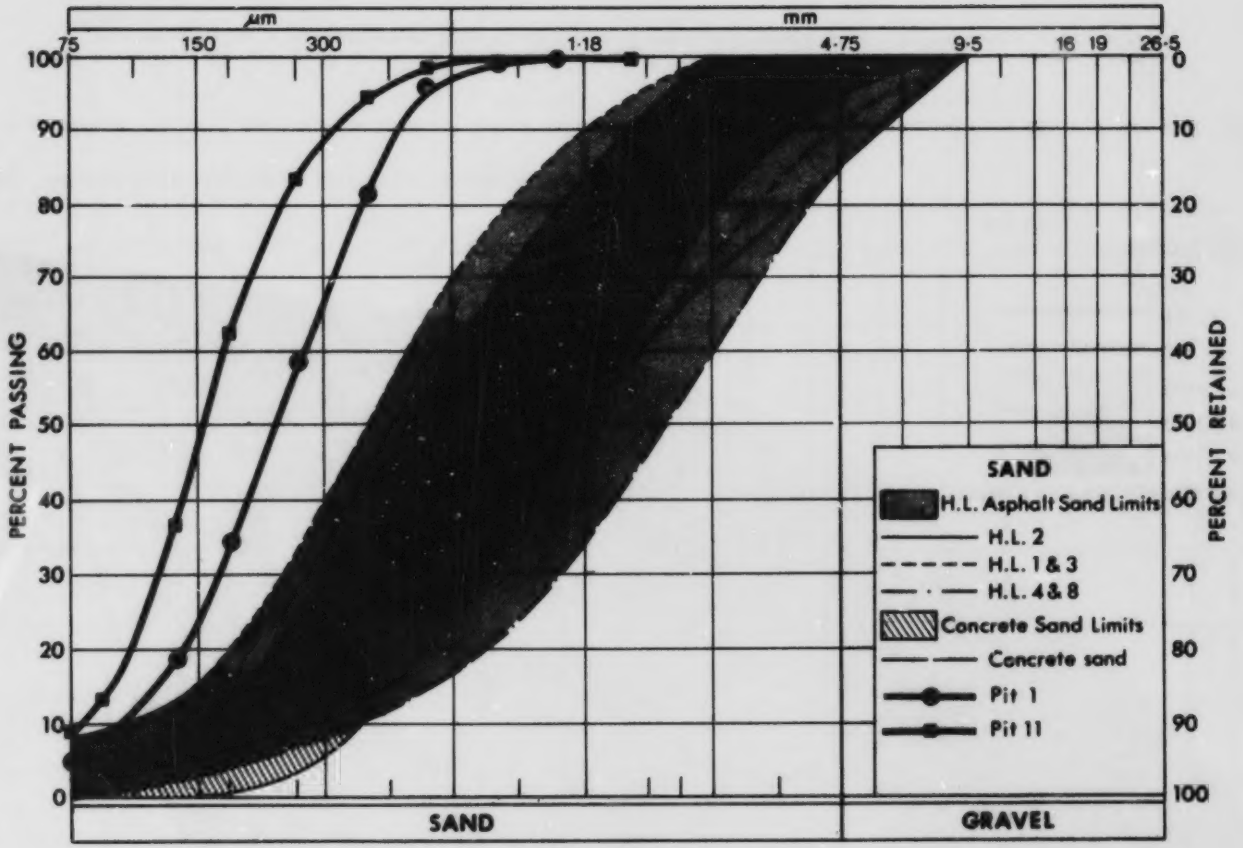


FIGURE 2b: AGGREGATE GRADING CURVES, TOWN OF DUNNVILLE;

Based on analysis of the sand fraction of the aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Forms 1002, 1979 and 1003, 1981).

NOTE:

Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

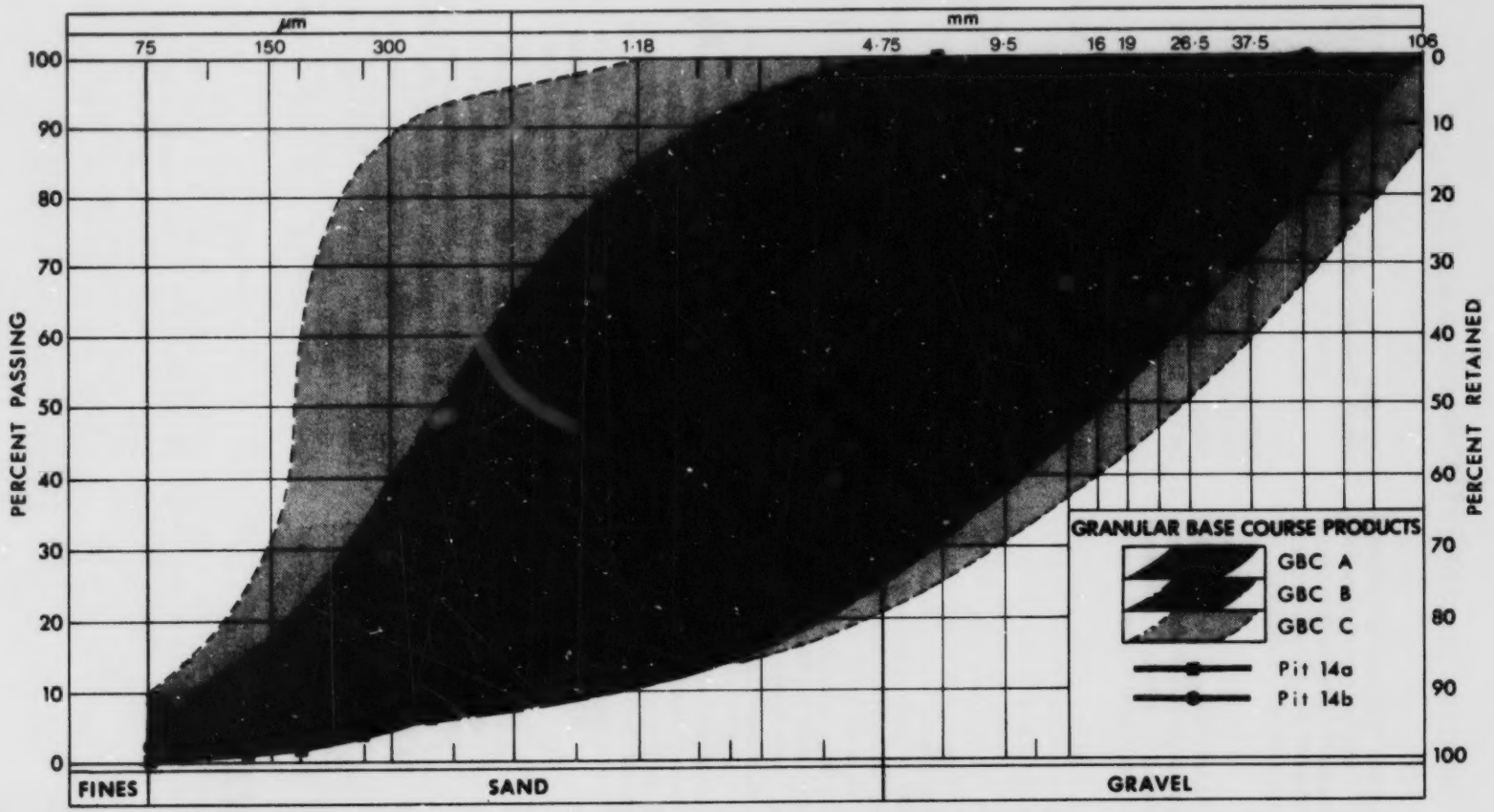


FIGURE 3: AGGREGATE GRADING CURVES, TOWN OF DUNNVILLE (after Feenstra, in prep. b);

Based on analysis of the total aggregate contained in unprocessed samples (gradation envelopes adapted from M.T.C. Form 1010, 1980).

NOTE: Information portrayed by grading curves refers strictly to a specific sample taken at the time of field investigation. Due to the inherent variability of sand and gravel deposits care should be exercised in extrapolating such information to the rest of the deposit.

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Proctor and Redfern Limited and
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APPENDIX B - GLOSSARY

ABRASION RESISTANCE

Tests such as the Los Angeles Abrasion Test are used to measure the ability of aggregate to resist crushing and pulverizing under conditions similar to those encountered in processing and use. Measuring resistance is an important component in the evaluation of the quality and prospective uses of aggregate. Hard, durable material is preferred for road building.

ABSORPTION CAPACITY

Related to the porosity of the rock types of which an aggregate is composed. Porous rocks are subject to disintegration when absorbed liquids freeze and thaw, thus decreasing the strength of the aggregate.

AGGREGATE

Any hard, inert, construction material (sand, gravel, shells, slag, crushed stone or other mineral material) used for mixing in various-sized fragments with a cement or bituminous material to form concrete, mortar, etc., or used alone for road building or other construction. Synonyms include mineral aggregate and granular material.

ALKALI-AGGREGATE REACTION

A chemical reaction between the alkalies of portland cement and certain minerals found in rocks used for aggregate. Alkali-aggregate reactions are undesirable because they can cause expansion and cracking of concrete. Although perfectly suitable for building stone and asphalt applications, alkali-reactive aggregates should be avoided for structural concrete uses.

BLENDING

Required in cases of extreme coarseness, fineness or other irregularities in the gradation of unprocessed aggregate. Blending is done with approved sand-sized aggregate in order to satisfy the gradation requirements of the material.

CAMBRIAN

The first period of the Paleozoic Era, thought to have covered the time between 570 and 500 million years ago; the Cambrian precedes the Ordovician Period.

CLAST

An individual constituent, grain or fragment of a sediment or rock, produced by the mechanical weathering of a larger rock mass. Synonyms include particle and fragment.

CRUSHABLE AGGREGATE

Unprocessed gravel containing a minimum of 35 percent coarse aggregate larger than the No. 4 sieve (4.75 mm) as well as a minimum of 20 percent greater than the 26.5 mm sieve.

DELETERIOUS LITHOLOGY

A general term used to designate those rock types which are chemically or physically unsuited for use as construction or road-building aggregates. Such lithologies as chert, shale, siltstone and sandstone may deteriorate rapidly when exposed to traffic and other environmental conditions.

DEVONIAN

A period of the geological past thought to have covered the span of time between 395 and 345 million years ago, following the Silurian Period. Rocks formed in the Devonian Period are among the youngest found in Ontario.

DOLOSTONE

A carbonate sedimentary rock consisting chiefly of the mineral dolomite and containing relatively little calcite (dolostone is also known as dolomite).

DRIFT

A general term for all unconsolidated rock debris transported from one place and deposited

in another; distinguished from underlying bedrock. In North America, glacial activity has been the dominant mode of transport and deposition of drift. Synonyms include overburden and surficial deposit.

DRUMLIN

A low, smoothly rounded, elongated hill, mound, or ridge composed of glacial materials. These landforms were deposited beneath an advancing ice sheet, and were shaped by its flow.

EOLIAN

Pertaining to the wind, especially with respect to landforms whose constituents were transported and deposited by wind activity. Sand dunes are an example of an eolian landform.

FINES

A general term used to describe the size fraction of an aggregate which passes (is finer than) the No. 200 mesh screen (.075 mm). Also described informally as "dirt", these particles are in the silt and clay size range.

GLACIAL LOBE

A tongue-like projection from the margin of the main mass of an ice cap or ice sheet. During the Pleistocene Epoch several lobes of the Laurentide continental ice sheet occupied the Great Lakes basins. These lobes advanced and retreated numerous times during the Pleistocene, producing the complex arrangement of glacial material and landforms found in southern Ontario.

GRADATION

The proportion of material of each particle size, or the frequency distribution of the various sizes which constitute a sediment. The strength, durability, permeability and stability of an aggregate depend to a great extent on its gradation. The size limits for different particles are as follows:

Boulder	more than 200 mm
Cobbles	75-200 mm
Coarse Gravel	26.5-75 mm
Fine Gravel	4.75-26.5 mm
Coarse Sand	2-4.75 mm
Medium Sand	0.425-2 mm
Fine Sand	0.075-0.425 mm
Silt, Clay	less than 0.075 mm

GRANULAR BASE COURSE

Components of the pavement structure of a road, which are placed on the subgrade and are designed to provide strength, stability and drainage, as well as support for surfacing materials. Several types have been defined: Granular Base Course A consists of crushed and processed aggregate and has relatively stringent quality standards in comparison to Granular Base Course B and C which are usually pit-run or other unprocessed aggregate.

HOT-LAID (OR ASPHALTIC) AGGREGATE

Bituminous, cemented aggregates used in the construction of pavements either as surface or bearing course (H.L. 1, 3 and 4), or as binder course (H.L. 2, 6 and 8) used to bind the surface course to the underlying granular base course.

LITHOLOGY

The description of rocks on the basis of such characteristics as color, structure, mineralogic composition and grain size. Generally, the description of the physical character of a rock.

MELTWATER CHANNEL

A drainage way, often terraced, produced by water flowing away from a melting glacier margin.

ORDOVICIAN

An early period of the Paleozoic Era thought to have covered the span of time between 500 and 435 million years ago.

PALEOZOIC ERA

One of the major divisions of the geologic time scale thought to have covered the time between 570 and 230 million years ago, the Paleozoic Era (or Ancient Life Era) is subdivided into six geologic periods, of which only four (Cambrian, Ordovician, Silurian and Devonian) can be recognized in southern Ontario.

PETROGRAPHIC EXAMINATION

An aggregate quality test based on known field performance of various rock types. The test result is a Petrographic Number (P.N.). The higher the P.N. the lower the quality of the aggregate.

PLEISTOCENE

An Epoch of the recent geological past including the time from approximately 1.8 million years ago to 7000 years ago. Much of the Pleistocene was characterized by extensive glacial activity and is popularly referred to as the "Great Ice Age".

POSSIBLE RESOURCE

Reserve estimates based largely on broad knowledge of the geological character of the deposit and for which there are few, if any samples or measurements. The estimates are based on assumed continuity or repetition for which there are reasonable geological indications.

SHALE

A fine-grained, sedimentary rock formed by the consolidation of clay, silt or mud and characterized by well developed bedding planes, along which the rock breaks readily into thin layers. The term shale is also commonly used for fissile claystone, siltstone and mudstone.

SILURIAN

An early period of the Paleozoic Era thought to have covered the time between 435 and 395 million years ago. The Silurian follows the Ordovician Period and precedes the Devonian Period.

SOUNDNESS

The ability of the components of an aggregate to withstand the effects of various weathering processes and agents. Unsound lithologies are subject to disintegration caused by the expansion of absorbed solutions. This may seriously impair the performance of road-building and construction aggregates.

TILL

Unsorted and unstratified rock debris, deposited directly by glaciers, and ranging in size from clay to large boulders.

WISCONSINAN

Pertaining to the last glacial period of the Pleistocene Epoch in North America. The Wisconsinan began approximately 100 000 years ago and ended approximately 7000 years ago. The glacial deposits and landforms of southern Ontario are predominantly the result of glacial activity during the Wisconsinan Stage.

APPENDIX C - GEOLOGY OF SAND AND GRAVEL DEPOSITS

The type, distribution, and extent of sand and gravel deposits in southern Ontario are the result of extensive glacial and glacially influenced activity in Wisconsinan time during the Pleistocene Epoch, approximately 100 000 to 7000 years ago. The deposit types reflect the different depositional environments that existed during the melting and retreat of the continental ice masses, and can readily be differentiated on the basis of their morphology, structure, and texture. The deposit types are described below.

GLACIOFLUVIAL DEPOSITS

These deposits can be divided into two broad categories: those that were formed in contact with (or in close proximity to) glacial ice, and those that were deposited by meltwaters carrying materials beyond the ice margin.

ICE-CONTACT TERRACES (ICT)

These are glaciofluvial features deposited between the glacial margin and a confining topographic high, such as the side of a valley. The structure of the deposits may be similar to that of outwash deposits, but in most cases the sorting and grading of the material is more variable and the bedding is discontinuous due to extensive slumping. The probability of locating large amounts of crushable aggregate is moderate, and extraction may be expensive due to the variability of the deposits both in terms of quality and grain size distribution.

KAMES (K)

Kames are defined as mounds of poorly sorted sand and gravel deposited by meltwater in depressions or fissures on the ice surface or at its margin. During glacial retreat, the melting of supporting ice causes collapse of the deposits producing internal structures characterized by bedding discontinuities. The deposits consist mainly of irregularly bedded and crossbedded, poorly sorted sand and gravel. The present forms of the deposits include single mounds, linear ridges (crevasse fillings) or complex groups of landforms. The latter are occasionally described as "undifferentiated ice-contact stratified drift" (IC) when detailed subsurface information is unavailable. Since kames commonly contain large amounts of fine-grained material and are characterized by considerable variability, there is generally a low to moderate probability of discovering large amounts of good-quality, crushable aggregate. Extractive problems encountered in these deposits are mainly the excessive variability of the aggregate and the rare presence of excess fines (silt- and clay-sized particles).

ESKERS (E)

Eskers are narrow, sinuous ridges of sand and gravel deposited by meltwaters flowing in tunnels within or at the base of glaciers, or in channels on the ice surface. Eskers vary greatly in size. Many, though not all eskers consist of a central core of poorly sorted and stratified gravel characterized by a wide range in grain size. The core material is often draped on its flanks by better sorted and stratified sand and gravel. The deposits have a high probability of containing a large proportion of crushable aggregate, and since they are generally built above the surrounding ground surface, are convenient extraction sites. For these reasons esker deposits have been traditional aggregate sources throughout southern Ontario, and are significant components of the total resources of many areas.

Some planning constraints and opportunities are inherent in the nature of the deposits. Because of their linear nature, the deposits commonly extend across several property boundaries leading to unorganized extractive development at numerous small pits. On the other hand, because of their form, eskers can be easily and inexpensively extracted and are amenable to rehabilitation and sequential land use.

UNDIFFERENTIATED ICE-CONTACT STRATIFIED DRIFT (IC)

This designation may include deposits from several ice-contact, depositional environments which usually form extensive, complex landforms. It is not feasible to identify individual areas of coarse-grained material within such deposits due to their lack of continuity and grain size variability. They are given a qualitative rating based on existing pit and other subsurface data.

OUTWASH (OW)

Outwash deposits consist of sand and gravel laid down by meltwaters beyond the margin of the ice lobes. The deposits occur as sheets or as terraced valley fills (valley trains) and may be very large in extent and thickness. Well developed outwash deposits have good horizontal bedding and are uniform in grain size distribution. Outwash deposited near the glacier's margin is much more variable in texture and structure. The probability of locating useful crushable aggregates in outwash deposits is moderate to high depending on how much information on size, distribution and thickness is available.

ALLUVIUM (AL)

Alluvium is a general term for clay, silt, sand, gravel, or similar unconsolidated material deposited during postglacial time by a stream as sorted or semi-sorted sediment, on its bed or on its floodplain. The probability of locating large amounts of crushable aggregate in alluvial deposits is low, and it has generally low value due to the presence of excess silt- and clay-sized material. There are few large postglacial alluvium deposits in Ontario.

GLACIOLACUSTRINE DEPOSITS

GLACIOLACUSTRINE BEACH DEPOSITS (LB)

These are relatively narrow, linear features formed by wave action at the shores of glacial lakes that existed at various times during the deglaciation of southern Ontario. Well developed lacustrine beaches are usually less than 20 feet (6 m) thick. The aggregate is well sorted and stratified and sand-sized material commonly predominates. The composition and size distribution of the deposit depends on the nature of the source material. The probability of obtaining crushable aggregate is high when the material is developed from coarse-grained materials such as a stony till, and low when developed from fine-grained materials. Beaches are relatively narrow, linear deposits, so that extractive operations are often numerous and extensive.

GLACIOLACUSTRINE DELTAS (LD)

These features were formed where streams or rivers of glacial meltwater flowed into lakes and deposited their suspended sediment. In southern Ontario such deposits tend to consist mainly of sand and abundant silt. However, in near-ice and ice-contact positions, coarse material may be present. Although deltaic deposits may be large, the probability of obtaining coarse material is generally low.

GLACIOLACUSTRINE PLAINS (LP)

The nearly level surface marking the floor of an extinct glacial lake. The sediments which form the plain are predominantly fine to medium sand, silt, and clay, and were deposited in relatively deep water. Lacustrine deposits are generally of low value as aggregate sources due to their fine grain size and lack of crushable material. In some aggregate-poor areas, lacustrine deposits may constitute valuable sources of fill and some granular base course aggregate.

GLACIAL DEPOSITS

END MORAINES (EM)

These are belts of glacial drift deposited at, and parallel to, glacier margins. End moraines commonly consist of ice-contact stratified drift and in such instances are usually called kame moraines. Kame moraines commonly result from deposition between two glacial lobes (interlobate moraines). The probability of locating aggregates within such features is moderate to low. Exploration and development costs are high. Moraines may be very large and contain vast aggregate resources, but the location of the best resource areas within the moraine is usually poorly defined.

EOLIAN DEPOSITS

WINDBLOWN DEPOSITS (WD)

Windblown deposits are those formed by the transport and deposition of sand by winds. The form of the deposits ranges from extensive, thin layers to well developed linear and crescentic ridges known as dunes. Most windblown deposits in southern Ontario are derived from, and deposited on, pre-existing lacustrine sand plain deposits. Windblown sediments almost always consist of fine to coarse sand and are usually well sorted. The probability of locating crushable aggregate in windblown deposits is very low.

APPENDIX D - GEOLOGY OF BEDROCK DEPOSITS

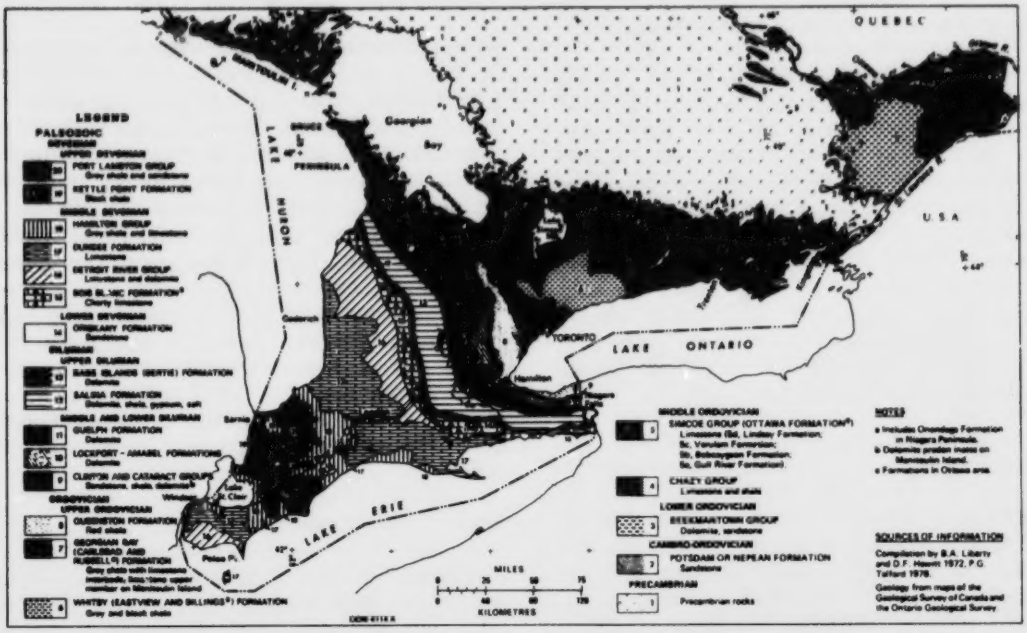

Figure 4 - Bedrock Geology of Southern Ontario

BEDROCK SUITABLE FOR CRUSHED STONE PRODUCTS

BASS ISLANDS FORMATION (UPPER SILURIAN)

(Includes the Bertie Formation of the Niagara Peninsula) Composition: Medium- to massive-bedded, aphanitic, brown dolostone with shaly partings. Thickness: 35 to 60 feet (11 to 18m) near Hagersville. Uses: Quarried for crushed stone on the Niagara Peninsula at Fort Erie, Cayuga, Hagersville, and Dunville. Los Angeles Abrasion Test: 17-35% loss; Absorption: 1.4%. Shaly parts are unsuitable for aggregate due to high soundness losses.

BOBCAYGEON FORMATION (MIDDLE ORDOVICIAN)

Composition: Compact, homogeneous, medium to thin-bedded, fine-grained limestone with some argillaceous and shaly partings. Thickness: The lower unit is 40 to 72 feet (12 to 22 m) thick in the east and the remainder of the formation is 40 feet (12 m). Uses: Quarried at Kirkfield and Marysville for crushed stone. The Bobcaygeon Formation has consistently acceptable quality for granular base course materials and concrete.

BOIS BLANC FORMATION (LOWER-MIDDLE DEVONIAN)

Composition: Brownish grey, medium-crystalline, medium- to thin-bedded, cherty limestone, commonly fossiliferous. Limestone may be silty or sandy in places. Thickness: 9 to 200 feet (3 to 61 m). Uses: Quarried at Hagersville, Cayuga, and Port Colborne for crushed stone. High chert content makes much of the material unsuitable for concrete aggregate. Los Angeles Abrasion Test: 14-28% loss; Soundness Test: 4-10% loss; Absorption: 0.7-2.0%.

DUNDEE FORMATION (MIDDLE DEVONIAN)

Composition: Fine- to medium-crystalline, brownish grey, medium- to thick-bedded, dolomitic limestone with shaly partings, sandy layers, and chert in some areas. Thickness: 60 to 160 feet (18 to 49 m). Uses: Quarried near Port Dover and Pelee Island for crushed stone.

Used at St. Marys for portland cement. Los Angeles Abrasion Test: 22-32% loss; Absorption: 0-4%.

GULL RIVER FORMATION (MIDDLE ORDOVICIAN)

Composition: Member A: thin- to thick-bedded, interbedded, grey argillaceous limestone and buff to green dolostone with a maximum thickness of 60 feet (18 m). Members B and C are dense, aphanitic limestones with argillaceous dolostone interbeds. Uses: Quarried at Kirkfield, Victoria County, and Uhthoff for crushed stone. The product is generally fresh and compact with good cubic-shaped factor, low clay content, low absorption, and low soundness losses. Smooth particle surfaces may cause adhesion problems for asphalt. There is some alkali reactivity in a few of the layers.

LOCKPORT AND AMABEL FORMATIONS (MIDDLE SILURIAN)

Composition: Amabel Formation (Waterdown to the Bruce Peninsula): massive, fine-crystalline dolostone, with reef facies dolostone near Georgetown. Lockport Formation (lateral facies equivalent to the Amabel Formation from Waterdown to Niagara Falls): thin- to massive-bedded, fine- to medium-grained dolostone. Thickness: Amabel Formation: maximum observed thickness of 84 feet (26 m). Lockport Formation: up to 130 feet (40 m). Uses: The Lockport and Amabel Formations have been used to produce lime, crushed stone, concrete aggregate and building stone throughout their area of occurrence, and are a resource of provincial significance. Los Angeles Abrasion Test: 21-35% loss; Soundness Test: 2.0% loss; Absorption: 0.4-1.6%.

ONONDAGA FORMATION (MIDDLE DEVONIAN)

(Equivalent to the Detroit River Group, with a textural change) Composition: Edgecliff Member: medium-bedded, fine- to medium-grained, dark grey cherty limestone with an estimated thickness of 25 to 30 feet (8 to 9 m). Clarence Member: massive-bedded, dark grey brown, fine-grained, very cherty limestone having an estimated thickness of 26 feet (8 m). Moorehouse Member: medium-bedded, dark grey brown or purplish brown, fine- to coarse-grained, variably cherty limestone with an estimated thickness of 15 to 25 feet (5 to 8 m). Uses: Quarried for crushed stone on the Niagara Peninsula at Welland and Port Colborne. High chert content makes much of the material unsuitable for concrete aggregate.

OTTAWA FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Phase (Lowville and Pamela Beds): shale, some sandstone and dolostone. Thickness: 100 feet (30 m). Middle Phase (Hull, Rockland, and Leray Beds): pure, thick-bedded, crystalline limestone. Thickness: 150 feet (46 m) near Ottawa. Upper Phase (Cobourg and Sherman Fall Beds): pure and impure crystalline limestone with few to numerous shaly partings, 450 to 475 feet (137 to 145 m) thick near Ottawa. Uses: The Leray, Rockland, and Hull Beds have been quarried extensively for crushed stone and for building stone. In addition, the Hull Beds are an excellent source of lime for cement production and agricultural uses.

OXFORD FORMATION (LOWER ORDOVICIAN)

Composition: Medium- to thick-bedded, grey dolostone, with some shaly partings. Thickness: 240 feet (73 m). Uses: Quarried for crushed stone (road and concrete aggregate) at Ottawa, Brockville, and Smiths Falls.

BEDROCK SUITABLE FOR LIME PRODUCTION AND OTHER CHEMICAL USES

DETROIT RIVER GROUP (MIDDLE DEVONIAN)

(Equivalent to the Onondaga Formation in the Niagara Peninsula, with a textural change) Composition: Near Beachville, the group consists of medium- to micro-crystalline, medium-bedded, high-purity limestone. It grades northwards near St. Marys to soft, evenly bedded, fine-grained dolostone with bituminous laminae. Massive, porous, reef facies material also occurs to the north (Formosa Reef Limestone). Thickness: 100 feet (30 m) at Beachville, 350 feet (107 m) at Clinton. Uses: The most important source of high-purity limestone in Ontario is the Lucas Formation of the Detroit River Group at Beachville. Detroit River limestone produces 80% of Ontario's cement. Its dolomitic reefal facies is also important for lime production to the north. It is generally unsuitable for crushed stone. The Anderdon Member of the Lucas Formation is quarried at Amherstburg for

crushed stone.

GRENVILLE MARBLE (PRECAMBRIAN)

Composition: Recrystallized white limestone and dolostone, fine- to coarse-grained, usually of high chemical purity. Uses: Lime production, but also in small amounts for terrazzo chips, poultry grit, decorative stone, and building stone.

GUELPH FORMATION (MIDDLE SILURIAN)

Composition: Aphanitic to medium-crystalline, thick-bedded, soft, porous dolostone, characterized in places by extensive vuggy, porous reefal facies dolostone of high chemical purity. The Guelph Formation and the underlying Amabel Formation have a combined thickness of 200 feet (61 m) on the Niagara Peninsula and more than 400 feet (122 m) on the Bruce Peninsula. Uses: The main use is for dolomitic lime in the construction industry. The formation is quarried near Hamilton and Guelph.

LINDSAY FORMATION (MIDDLE ORDOVICIAN)

Composition: Lower Member: fine-crystalline, rubbly, nodular-weathering limestone. Upper Member: grey calcareous claystone with shaly partings and bioclastic layers. The rock is "soft" and weathers to rubble. Both members are characterized by low dolomite content and by numerous clayey partings. Uses: Quarried at Picton, Ogden Point and Bowmanville for cement. The formation is generally unsuitable for crushed stone, concrete aggregate, or granular base course.

VERULAM FORMATION (MIDDLE ORDOVICIAN)

Composition: Fossiliferous, pure to argillaceous limestone and interbedded calcareous shale. The rock is not resistant to erosion and commonly weathers to rubble. Thickness: 200 to 300 feet (61 to 91 m). Uses: Quarried at Picton, Ogden Point, and Mara Township for cement. The formation is unsuitable for crushed stone due to clay impurities, many clayey interbeds, and low abrasion resistance, high soundness losses and poor freeze and thaw resistance.

BEDROCK SUITABLE FOR BRICK AND TILE MANUFACTURE

GEORGIAN BAY FORMATION (UPPER ORDOVICIAN)

(Formerly known as the Meaford-Dundas and Blue Mountain shales in the Toronto and Bruce Peninsula areas) Composition: Soft, fissile, blue grey shale with limey or sandy lenses in a few places. Thickness: 640 feet (195 m) at Toronto. Uses: Several producers in Metro Toronto and Cooksville produce brick and structural tile. Lightweight aggregate is also produced at Streetsville by heat expansion of the shale.

HAMILTON GROUP (MIDDLE DEVONIAN)

Composition: Grey shale with interbeds of crystalline and cherty limestone. The group has six formations, but only the Arkona is of commercial value. It is a soft, light grey, calcareous shale which is plastic and easily worked when wet. Thickness: 80 to 300 feet (24 to 91 m). Uses: The Arkona Formation is extracted at Thedford and near Arkona for production of drainage tile and brick.

QUEENSTON FORMATION (UPPER ORDOVICIAN)

Composition: Red, thin- to thick-bedded, sandy to argillaceous shale with green mottling and banding. Thickness: 400 to 500 feet (122 to 152 m). Uses: There are several large shale quarries developed in the Queenston Formation in the Toronto-Hamilton region and one at Russell, near Ottawa. All produce brick for construction. The Queenston Formation is the most important source material for brick manufacture in the Province.

BEDROCK SUITABLE FOR OTHER INDUSTRIAL PRODUCTS

NEPEAN (POTSDAM) FORMATION (CAMBRO-ORDOVICIAN)

Composition: Creamy, coarse-grained, silica sandstone. Uses: Quarried throughout its area of outcrop for building stone, decorative stone, abrasives, and for glass making.

SALINA FORMATION (UPPER SILURIAN)

Composition: Grey and red shale, brown dolomite, and, in places, salt, anhydrite, and gypsum.

The formation consists predominantly of evaporite deposits with up to eight members identified. Uses: Gypsum is mined at Hagersville, Caledonia, and Drumbo. Salt is mined at Goderich and is produced from brine wells at Amherstburg, Windsor, and Sarnia.

WHITBY FORMATION (UPPER ORDOVICIAN)

(Formerly known as Collingwood Shale near Toronto) Composition: Brown to black fissile shale. Uses: Quarried at Bowmanville for use in cement production. Testing indicates that the Whitby Formation may produce satisfactory lightweight expanded aggregate.

TP OF WEST LINCOLN
TOWN OF DUNNVILLE
R.M. OF NIAGARA
R.M. OF HALDIMAND-NORFOLK
TOWN OF HALDIMAND
Creek
Canboro
Auto Wreckers
Orchard
Darling Road
BM 594
Dump
BM 599
CANADIAN NATIONAL
Greenhouse
Greenhouses
Golf Course
Gravel Pit
Silo
Attercliffe Station
MICHIGAN CENTRAL
Moulton Station
TP OF WAINFLEET
TOWN OF DUNNVILLE
GRAND TRUNK
HAMILTON & BUFFALO
Mount Carmel
Drain
South
North
Forks
Attercliffe
Osweo
Creek
Dam
S 4 LP C
S 3 LD C
S 3 WD
S 2 WD
S 4 AL
I
II
III
IV

Ministry of Natural Resources

Ontario

Hon. Alan W. Pope
Minister

J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWN OF DUNNVILLE
REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 1
DISTRIBUTION OF SAND AND GRAVEL DEPOSITS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13
30 L/14
30 M/4

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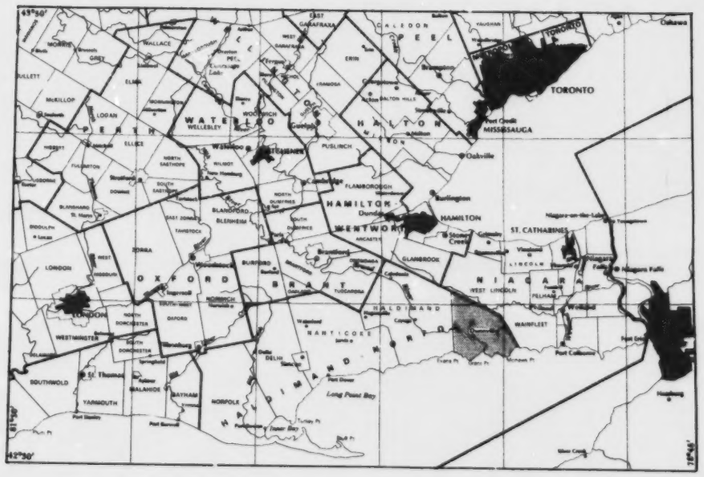


SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

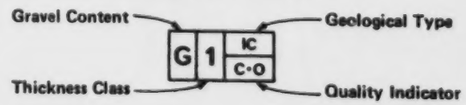
Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

● 3 — Unlicenced sand or gravel pit*; Property number: see Table 2.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G — Greater than 35% gravel

DUNNVILLE
Byng
CONNOR BAY
MOHAWK BAY
Splatt Bay
Port Maitland
Stromness
Mount Carmel
Lowbanks
Blott Point
Low Point
Grant Point
Rock Point
Mohawk Pt
Mohawk Island
Tweed
Gravel Pit
Quarry
Airfield (abandoned)
Gypsum Settling Beds
Acid Tanks
Filtration Plant
Youth Camp
YWCA Camp
Orchard Provincial Park
Home for the Aged
Poultry Farm
Golf Course
Greenhouses
Greenhouse
Orchard
Dump
Marina
Old Tank
Transformer
Campsite
Ditch
Drain
Creek
CANADIAN NATIONAL
CITY OF HAMILTON & BUFFALO
R.M. OF HALDIMAND-NORFOLK
R.M. OF HALDIMAND
MOUL
BAY
BM 591
BM 585
BM 588
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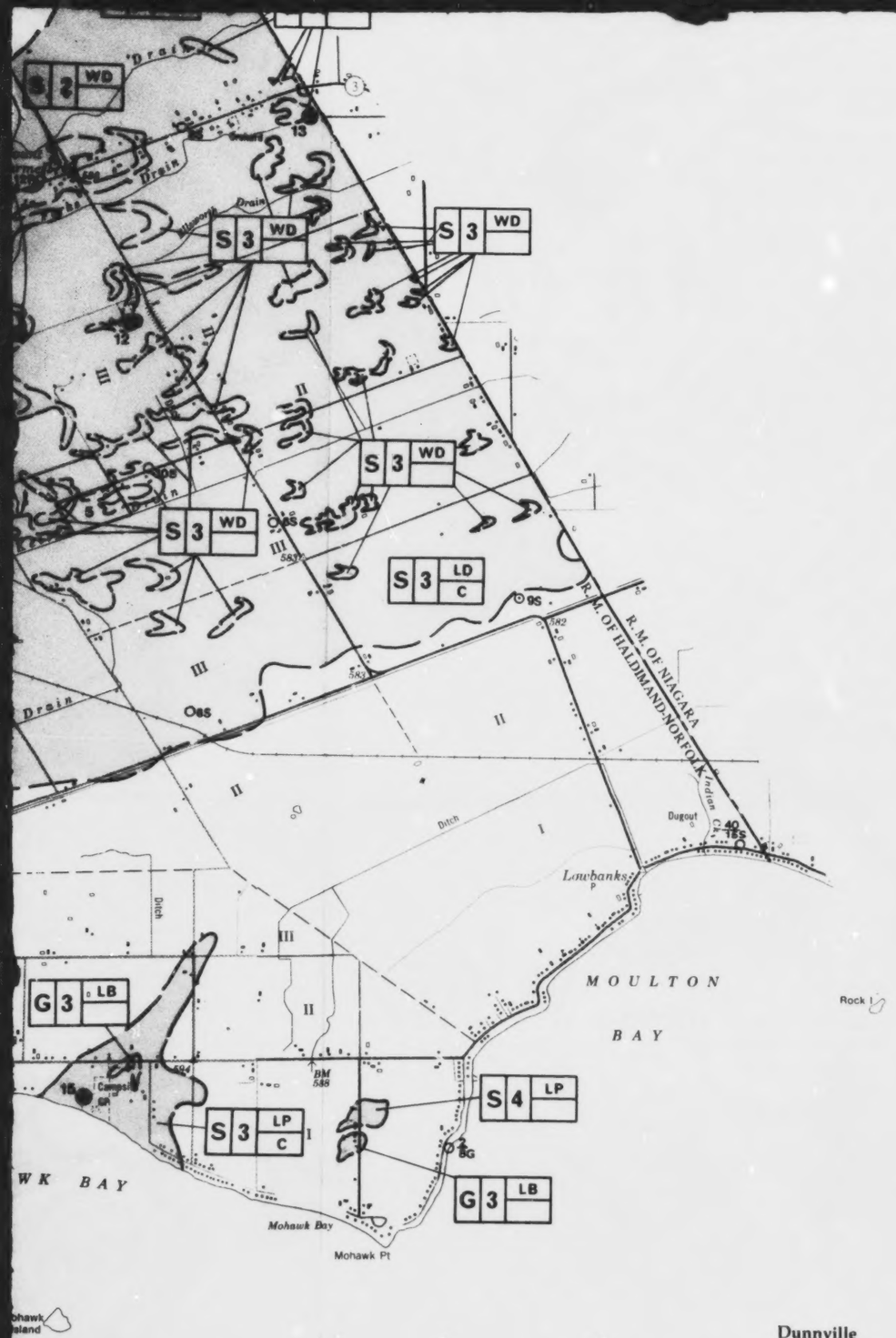
S 3 LD C
S 3 LP C
S 4 LP
G 3 LB



SYMBOLS

(Some symbols may not apply to this map.)

Geological and aggregate thickness boundary. Shading indicates deposit area.

Buried geological and aggregate thickness boundary. Shading indicates deposit area.

Municipal boundary.

2 — Licenced property boundary; Property number: see Table 2.

3 — Unlicenced sand or gravel pit*; Property number: see Table 2.
*Abandoned pit or wayside pit operating on demand under authority of a permit.

DU-TH-2 — Selected test hole location; Identification number: see Table 7.

6 / 23 G — Selected drilled water well location; reported thickness of material (in feet); reported type of material (number only - overburden, T - till, G - gravel, S - sand, C - clay, Bk - bedrock).

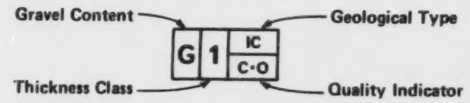
G 1 IC C·O — Deposit Symbol: see below.

Texture symbol: see below; see Figures 2 & 3.

TEXTURE SYMBOL

The Texture Symbol provides quantitative assessment of the grain size distribution at a sampled location. The relative amounts of gravel, sand, silt and clay in the sampled material are shown graphically by the subdivision of a circle into proportional segments. The above example shows a hypothetical sample consisting of 45% gravel, 35% sand and 20% silt and clay.

DEPOSIT SYMBOL



Deposits are identified by Gravel Content, Thickness Class, Geological Type and Quality Indicator. Gravel Content is expressed as a percentage of gravel-sized material (i.e. material retained on the 4.75 mm sieve). Thickness Class is based on potential aggregate tonnage per acre. Geological Type refers to geologic origin. Quality Indicator describes objectionable grain size and lithology.

Gravel Content

G	Greater than 35% gravel.
S	Less than 35% gravel.

Thickness Class

Class	Average Thickness in feet (metres)	Tons per acre (Tonnes per hectare)
1	greater than 20 (> 6)	greater than 50,000 (> 112 000)
2	10-20 (3-6)	25,000-50,000 (56 000 - 112 000)
3	5-10 (1.5-3)	12,500 - 25,000 (28 000 - 56 000)
4	less than 5 (< 1.5)	less than 12, 500 (< 28 000)

Geological Type

AL	Older Alluvium	**K**	Kame
E	Esker	**LB**	Lacustrine Beach
EM	End Moraine	**LD**	Lacustrine Delta
IC	Undifferentiated Ice-Contact Stratified Drift	**LP**	Lacustrine Plain
ICT	Ice-Contact Terrace	**OW**	Outwash
		WD	*Windblown Forms*

(see Appendix C for descriptions of Geological Types)

Quality Indicator

	If blank, no known limitations present.
C	Clay and/or silt (fines) present in objectionable quantities.
L	Deleterious lithologies present.
O	Oversize particles or fragments present in objectionable quantities.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

Licence data from District and Regional Offices, Ontario Ministry of Natural Resources.

Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

Test hole data from Aggregate Assessment Office, Ontario Geological Survey, Ontario Ministry of Natural Resources.

Selected drilled water well data from the Ontario Ministry of the Environment.

Drilling data from the Petroleum Resources Section, Ontario Ministry of Natural Resources.

Geology by: B. H. Feenstra, 1972, 1974, 1975.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

This map is to accompany O.G.S. Aggregate Resources Inventory Paper 67.

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Issued 1984.

Information quoted for an individual test hole or pit refers to a specific sample or face. Care should be exercised in extrapolating such information to other parts of the deposit.

TP OF WEST LINCOLN
TOWN OF DUNNVILLE

R. M. OF NIAGARA
R. M. OF HALDIMAND-NORFOLK

R. M. OF HALDIMAND-NORFOLK

TOWN OF DUNNVILLE
TOWN OF HALDIMAND

TP OF WAINFLEET
TOWN OF DUNNVILLE

TP OF WAINFLEET
TOWN OF DUNNVILLE

Creek

Canboro

Auto Wreckers

Orchard

Darling Road

CANADIAN NATIONAL

MICHIGAN CENTRAL

Attercliffe Station

Moulton Station

Dump

BM 594

BM 589

CANADIAN NATIONAL

Greenhouse

Orchard

Greenhouses

Golf Course

Gravel Pit

Greenhouse

TORONTO HAMILTON & BUFFALO

Dam

Mount Carmel

Forks

Drain

Ellsworth Drain

Orchard

I

II

III

IV

A

1

2

3

4

5

6

7

8

9

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11

12

13

586

587

591

594

N

Ontario

Ministry of Natural Resources

Hon. Alan W. Pope
Minister

J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWN OF DUNNVILLE
REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 2
SELECTED SAND AND GRAVEL RESOURCE AREAS

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: **30 L/13**
30 L/14
30 M/4

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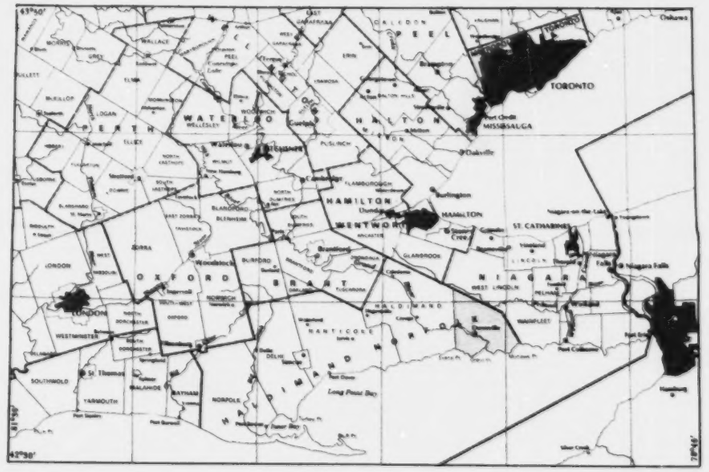

SYMBOLS

(Some symbols may not apply to this map.)

— — — — Geological and aggregate thickness boundary.

•••••••••••••••••• Buried geological and aggregate thickness boundary.

———— Municipal boundary.

Selected sand and gravel resource area; Primary significance; Deposit number; see Table 3.

DUNNVILLE
Port Maitland
Byng
Mount Carmel
Stromness
Loubanks
Splatt Bay
CONNOR BAY
MOHAWK BAY
MOUL
BAY
Grant Point
Low Point
Blott Point
Rock Point
Mohawk Island
Mohawk Pt
Mohawk Bay
Gypsum Settling Beds
Filtration Plant
Youth Camp
YWCA Camp
Rock Point Provincial Park
Home for the Aged
Golf Course
Greenhouses
Greenhouse
Orchard
Orchards
Quarry
Gravel Pit
Airfield (abandoned)
Dump
Hospital
Factory
Canning
Mill
GP
Dam
Park
Campsite
Acid Tanks
Oil Tank
Pumping Station
Transformer
Ditch
Drain
Creek
Hughson Drain
Ellsworth Drain
Tweed Drain
South Drain
CANADIAN NATIONAL
TORONTO HAMILTON & BUFFALO
R. M. OF HALDIMAND-NORFOLK
R. M. OF HALDIMAND-NORFOLK
R. M. OF NIAGARA
TOWNLINE OF DUNNVILLE
BM 589
BM 585
BM 588
588
586
580
582
801
I
II
III
IV
V
1
2
3
4
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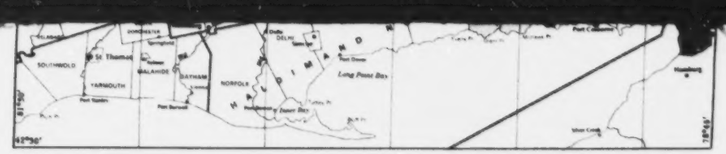
14
15



SYMBOLS

(Some symbols may not apply to this map.)

- Geological and aggregate thickness boundary.
- Buried geological and aggregate thickness boundary.
- Municipal boundary.
- (2) Selected sand and gravel resource area; Primary significance; Deposit number: see Table 3.
- Selected sand and gravel resource area; Secondary significance.
- Selected sand and gravel resource area; Tertiary significance.
- 2 Licenced property boundary; Property number: see Table 2.
- ● 3 Unlicenced sand or gravel pit*; Property number: see Table 2.
  *Abandoned pit or wayside pit operating on demand under authority of a permit.

SOURCES OF INFORMATION

Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

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TP OF WEST LINCOLN
TOWN OF DUNNVILLE

R. M. OF NIAGARA
R. M. OF HALDIMAND-NORFOLK

R. M. OF HALDIMAND-NORFOLK

TOWN OF DUNNVILLE
TOWN OF HALDIMAND

SALINA FORMATION

SALINA FORMATION

TP OF WAINFLEET
TOWN OF DUNNVILLE

TP OF WAINFLEET
TOWN OF DUNNVILLE

CANADIAN NATIONAL

CANADIAN NATIONAL

MICHIGAN-CENTRAL

TORONTO, HAMILTON & BUFFALO

Canboro

Oswego Creek

Darling Road

Attercliff Station

Moulton Station

Mount Carmel

Auto Wreckers

Orchard

Dump

Silo

Dam

Greenhouse

Greenhouses

Gravel Pits

Golf Course

Drain

North Forks Drain

South Forks Drain

Ellsworth Drain

BM 594

BM 599

606

062

050

044

041

057

064

072

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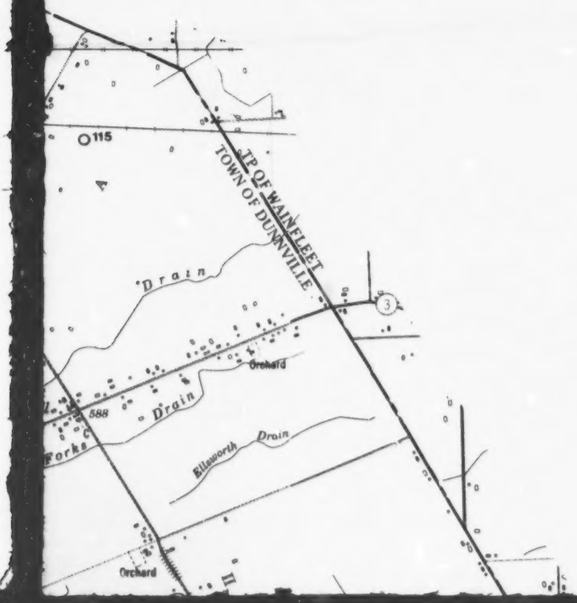

Ministry of Natural Resources
Ontario

Hon. Alan W. Pope
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J. R. Sloan
Deputy Minister

ONTARIO GEOLOGICAL SURVEY
AGGREGATE RESOURCES INVENTORY

TOWN OF DUNNVILLE
REGIONAL MUNICIPALITY OF HALDIMAND-NORFOLK

MAP 3
BEDROCK RESOURCES

Scale 1:50 000

Mile 1 0 1 Mile

Metres 1000 0 1 Kilometre

NTS Reference: 30 L/13
30 L/14
30 M/4

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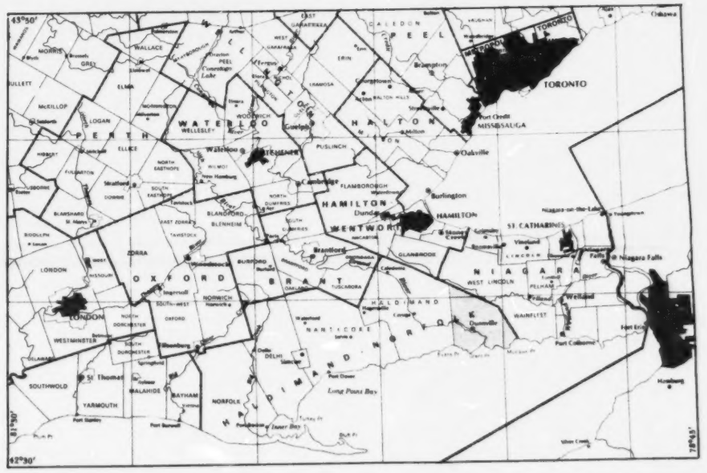

LEGEND

PALEOZOIC

DEVONIAN

MIDDLE DEVONIAN

ONONDAGA FORMATION
Cherty limestone

LOWER TO MIDDLE DEVONIAN

BOIS BLANC FORMATION
Cherty limestone

SYMBOLS

(Some symbols may not apply to this map.)

- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour: 25 foot (8 m) interval.
- Municipal boundary.
- (2) Selected bedrock resource area; Deposit number: see Table 6.

DUNNVILLE

SALINA FORMATION

BERTIE FORMATION

ONONDAGA FORMATION

BOIS BLANC FORMATION

CONNOR BAY

MOHAWK BAY

MOULT BAY

CANADIAN NATIONAL

TORONTO HAMILTON & BUFFALO

R.M. OF HALDIMAND-NORFOLK

R.M. OF NIAGARA

WAINFLEET

Byng

Splatt Bay

Port Maitland

Rock Point

Mohawk Island

Mohawk Pt

Blott Point

Low Point

Grant Point

Filtration Plant

Mount Carmel

Lowbanks

Strommess

Tweed

Kelly Drain

Maple Dent Drain

Boughner Drain

Ellsworth Drain

Mohawk Bay

Provincial Park

Campsite

YWCA Camp

Home for the Aged

Hospital

Cannery

Factory

Marina

Gas Tank

Oil Tank

Transformer

Gravel Pits

Golf Course

Greenhouses

Greenhouse

Orchard

Orchards

Dump

Dam

Park

Cemetery

Rock Point

Gypsum Settling Basin

Acid Tanks

Poultry Farm

Silos

Campsite

Ditch

Drain

Creek

Forks

North

South

1b

LEGEND

PALEOZOIC

DEVONIAN

MIDDLE DEVONIAN

ONONDAGA FORMATION
Cherty limestone

LOWER TO MIDDLE DEVONIAN

BOIS BLANC FORMATION
Cherty limestone

SILURIAN

UPPER SILURIAN

BERTIE FORMATION
Dolostone

SALINA FORMATION
Dolostone, shale, gypsum, salt

SYMBOLS

(Some symbols may not apply to this map.)

- Geological formation boundary.
- Geological formation member boundary.
- Formation thickness boundary (see text).
- 25 — Drift thickness contour: 25 foot (8 m) interval.
- Municipal boundary.
- (2) Selected bedrock resource area; Deposit number: see Table 6.
- Bedrock exposed or near surface; covered by less than 3 feet (1 m) of overburden: see Table 4.
- Bedrock covered by 3 to 25 feet (1 to 8 m) of overburden: see Table 4.
- Bedrock covered by 25 to 50 feet (8 to 15 m) of overburden: see Table 4.
- x Isolated bedrock outcrop.
- Q2 Licenced quarry boundary; Property number: see Table 5.
- Q3 Unlicenced quarry*; Property number: see Table 5. *Abandoned quarry or wayside quarry operating on demand under authority of a permit.
- 28 Selected drilled waterwell location; reported depth to bedrock (in feet).

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Base map by Surveys and Mapping Branch, Ontario Ministry of Natural Resources.

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Aggregate suitability data from the Engineering Materials Office, Ontario Ministry of Transportation and Communications.

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Geology by: B. H. Feenstra, in preparation.
B. H. Feenstra and M. Troper, 1982.
B. A. Liberty, B. H. Feenstra and P. G. Telford, 1976.
P. G. Telford and G.A. Tarrant, 1975a, b.
M.A. Vos, 1969.

Compilation and Drafting by: Staff of the Aggregate Assessment Office.

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